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On the carbon premium in Swiss stock returns*

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Abstract

This paper evaluates whether CO_2 emission levels or emission intensities are firm characteristics that drive Swiss firms' stock returns. We show that standard characteristics such as size and the book-to-market equity ratio are more important determinants of firm-level stock returns than are CO_2 levels (intensities). Brown firms (high CO_2 levels or intensities) tend to be large and exhibit low book-to-market equity ratios, whereas their green counterparts are small and exhibit high book-to-market equity ratios. This explains why return differences between brown and green firms are statistically indistinguishable from zero after controlling for exposures to standard risk factors.

JEL: G12, Q54
Keywords: climate change, CO_2 emissions, event study, risk premium

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1 Introduction

Theory suggests that firms' stock market valuations reflect risks associated with policies aimed at transitioning from a carbon-intensive economy to a carbon-light economy (Bansal, Ochoa, and Kiku, 2016; Pástor, Stambaugh, and Taylor, 2021; Hsu, Li, and Tsou, 2023). Hence, stock market investors should require extra compensation for exposure to risks associated with less climate-friendly firms. Confirming this theoretical link, Bolton and Kacperczyk (2021, 2023) used panel regressions to show that higher CO_2 emission levels of a firm are associated with higher stock returns.

However, Aswani, Raghunandan, and Rajgopal (2023) and Bauer, Huber, Rudebusch, and Wilms (2022) found that the link between firm-level CO_2 emission levels and stock returns is sensitive to the choice of control variables in the panel regressions and to the definition of brown versus green firms. Moreover, Zhang (2024) highlighted that the evidence of stock returns increasing with higher CO_2 levels (Bolton and Kacperczyk, 2021, 2023) reflects that firm-level CO_2 levels in a given year are correlated with firms' sales. Accounting for the publication lag of CO_2 emissions data breaks the positive link between CO_2 levels and firm-level stock returns. Furthermore, evidence on the basis of portfolio methods suggests that there is no carbon premium, i.e., no evidence of significant cross-sectional differences between returns on portfolios comprised of stocks of firms with high (brown) and low (green) CO_2 levels or high or low CO_2 intensities (emission levels divided by revenues) in the U.S. (Bauer et al., 2022; Huij, Laurs, Stork, and Zwinkels, 2023; Pástor, Stambaugh, and Taylor, 2022).

Against this background, this paper takes an asset pricing perspective and focuses on portfolio methods to address three research questions. The first question is whether there is a carbon premium in Swiss stock returns at all, i.e., whether there is a significant return difference between brown and green stock portfolios. Second, this paper empirically evaluates whether the carbon premium in Swiss stocks reflects exposure to standard measures of systematic stock market risk. Finally, we assess whether the Swiss carbon premium responds to daily news about climate-related risks.

This paper is not the first to focus on Switzerland and the question of whether there is evidence of a carbon premium in Swiss stock returns. Berthold (2024) studied the financial and real economic responses to climate policy risks in Switzerland by building on the work of Ardia, Bluteau, Boudt, and Inghelbrecht (2023) and constructing a Swiss climate policy index from Swiss media articles. Innovations in this index, derived in a structural vector-autoregressive model (SVAR), are associated with Swiss GDP growth. In addition, Berthold (2024) used panel regressions over rolling time windows to show that brown firms perform significantly worse than their green counterparts in response to events associated with increased climate policy risks. This finding is in line with U.S. evidence on the link between (unexpected changes in) climate change concerns and daily stock returns (Ardia et al., 2023; Faccini, Matin, and Skiadopoulos, 2023; Huij et al., 2023) and holds when examining a zero-cost portfolio of buying brown stocks and shorting green stocks.

Our main value added to the work of (Berthold, 2024) is fourfold. First, we show that CO_2 levels and CO_2 intensities are strongly correlated with characteristics such as size (log market value) and the book-to-market equity ratio of Swiss firms. These two characteristics are important determinants of cross-sectional differences in firm-level stock returns (Fama and French, 1992). In our sample of Swiss firms, brown firms are large and exhibit low book-to-market equity ratios, whereas their green counterparts are small and exhibit high book-to-market equity ratios. Time series regressions in the spirit of Fama and French (1993) show that CO_2 levels or CO_2 intensities provide no information about stock returns beyond the size (market capitalization) or the book-to-market equity ratio of a firm. This result is in line with evidence from the U.S. provided in the appendix to Bauer et al. (2022). Second, Zhang (2024) showed that taking the publication lag of CO_2 emission levels into account is crucial when assessing the link between CO_2 levels (intensities) and stock returns. We account for this publication lag in all of our empirical analyses. Third, running unbalanced panel regressions and controlling for the impact of size differences and differences in book-to-market equity on firm-level stock returns corroborates our main results based on portfolio methods. Finally, we show that the responses of the Swiss carbon premium to global climate change concerns or to events indicating greater risks for brown firms due to the transition to a more climate-friendly economy are relatively weak when we additionally control for risk factors capturing the effects of size and the book-to-market equity ratio on firms' stock returns.

Taken together, our empirical analyses suggest that investors in the Swiss stock market have not yet regarded the climate-friendliness of a firm as a key driver of its stock return. Other characteristics, such as the firm size and the ratio of book equity to market equity, are more important determinants of Swiss stock returns in our sample period between July 2010 and June 2024.

The remainder of the paper is organized as follows. Section 2 provides details about the data and their sources. Section 3 describes the formation of portfolios to distinguish between brown and green stocks. Section 4 presents the main empirical results. Section 5 concludes.

2 Data and sources

2.1 CO_2 emissions, balance sheet and stock market data

We closely follow Bauer et al. (2022) and gather firm-level data through Worldscope's company accounts for Switzerland (WSCOPESW), which contain all companies publicly traded in Switzerland. We remove firms listed in foreign currencies and participation certificates from our sample. For each firm, we collect data about their annual CO_2 emissions, revenue, and book-to-market equity ratio, as well as their market value and total returns, to build portfolios consisting of firms with low (green) and high (brown) CO_2 emissions and investigate their returns.

We use the sum of scope 1 (ENERDP024) and scope 2 (ENERDP025) CO_2 equivalent emissions in tons as defined by the greenhouse gas (GHG) protocol to measure the emissions generated by each company. Scope 1 emissions, also known as direct emissions, stem from sources that are owned or controlled by the company, whereas the emissions generated during the production of the electricity, steam heat and cooling used by the company fall into scope 2 emissions. We omit scope 3 emissions in our baseline estimation, which include all other indirect emissions from sources not owned or controlled by the company (e.g., through purchases of materials or the use of goods/services after being sold to customers), because the GHG protocol requires only scope 1 and 2 emissions to be reported (Ranganathan and Bhatia, 2004). Scope 3 emissions must be estimated either by the firm itself or by the data providers, and there tend to be inconsistencies between estimated firm-level scope 3 emissions across providers (Busch, Johnson, and Pioch, 2022).

Furthermore, Aswani et al. (2023) showed that scope 3 emissions are strongly correlated with firm characteristics, such as size. However, all of the qualitative results of this paper remain unaltered if we additionally consider scope 3 emissions from Worldscope.

As noted by Bauer et al. (2022), an energy-efficient company could emit more CO_2 than one with a much lower efficiency simply because it is larger. To account for these differences in size, we follow Bauer et al. (2022) and use a measure of the CO_2 intensity defined as the sum of scope 1 and 2 emissions divided by the yearly total revenues (WC01001) to distinguish between brown and green firms. The total revenues are defined as the gross sales and other operating revenues, returns, and allowances. The source of the annual data is LSEG Datastream. At the time of writing, this source did not allow us to distinguish between the scope 1 and scope 2 emissions reported by firms and those estimated by LSEG Datastream. However, this source provides the most comprehensive information about the CO_2 levels of listed Swiss firms. Therefore, we decided to follow Berthold (2024) and work with these emissions data.

Furthermore, we employ information about the book-to-market equity ratio (computed from MTBV) of the companies in our sample as a control variable and construct one of the standard risk factors on the Swiss stock market. The book-to-market ratio of a company is the balance sheet value of common equity divided by the market value of the common equity of a company. The source of these data is LSEG Datastream.

We also use monthly or daily stock return and market value (MV) data from LSEG Datastream. The returns on the stocks of the sample companies are computed as the percentage change in the respective total return index (RI). The total return index assumes that dividends are directly reinvested. We use the market value of each company to compute the value-weighted returns on brown and green stock portfolios. Furthermore, we employ the market value as a control variable in the panel regressions and compute the standard risk factors on the Swiss stock market.

Again, following Bauer et al. (2022), we build brown and green portfolios using only information available to investors at the time of portfolio formation. Therefore, we lag the yearly CO_2 levels (intensities) by one year, as they are usually published in the middle of the following year. This means that, for a company to be in our sample in a given year, it must have data points for lagged CO_2 levels, total revenue, book-to-market equity, total returns, and market value.[1] As is standard in the literature (Bauer et al., 2022; Fama and French, 1993), we allocate firms into portfolios in July of each year on the basis of the information available in June.

As shown in Figure 1, the emission variables constrain the sample period because we require a sufficient number of firms to build the stock portfolios and exploit the diversification effects associated with portfolio formation. The first companies started to report their CO_2 emission levels in 2003, but it was only in 2010, when the number of companies with all data points increased from 15 to 28, that the number of firms was sufficient for our baseline portfolio formation. Consequently, the sample period spans from July 2010 to June 2024. The year 2010 is also the starting year of the assessment of the G7 countries' green and brown stock portfolios by Bauer et al. (2022).

[Figure 1 about here]

When a company goes public, it is usually listed and traded for many years. As shown in Figure 2, the large majority of companies remain in the sample until the end of the observation period once they have entered it. Some exit the sample before the end of the observation period (delistings, mergers/acquisitions, bankruptcies). Other companies are only a part of the sample for a single year or are temporarily missing from it for a few years. However, since these cases are a minority, we judge our sample to be representative and consistent over time.

[Figure 2 about here]

2.2 Climate Change Concerns Data

We evaluate whether the stock market performance of green and brown stocks is associated with movements in global investors' concerns about the climate (Ardia et al., 2023; Faccini et al., 2023). To approximate these concerns, we use the Media Climate Change Concerns Index (MCCC) developed by Ardia et al. (2023), which

[1] The monthly variables (total returns, market value) need to be available in July as this is when the portfolios are constructed. Missing values in other months are tolerated.

measures and aggregates the climate-related risk and negativity in each article from 10 major U.S. newspapers (e.g., NYT, WSJ) and two newswires (Associated Press and Reuters). Hence, we take the MCCC as a stand-in for a global media climate change concerns index.

We use the daily version of the MCCC and follow the methodology of Ardia et al. (2023) to extract the Unexpected Media Climate Change Concerns Index (UMC) which is defined as the prediction error (ϵ_t) of the following rolling window (1,000 working days, which equates to approximately five years) autoregressive model:

$$MCCC_t = \alpha + \beta^{MCCC} MCCC_{t-1} + \gamma' \mathbf{x_{t-1}} + \epsilon_t \tag{1}$$

where $\mathbf{x}$ denotes the vector of control variables. Appendix A provides the list of control variables.

3 Brown and green stock portfolios

We closely follow Bauer et al. (2022) in building stock portfolios of green and brown firms. This means that we use either total (scope 1 and scope 2) CO_2 emission levels or emissions intensity (total emissions divided by revenue) to distinguish between green and brown firms. In addition, we compute three distinct measures of brown-minus-green (BMG) portfolio return spreads: (1) equally-weighted simple spread, (2) value-weighted simple spread, and (3) size-adjusted spread. For each of them, we create the underlying brown and green portfolios once a year in July, which is when the CO_2 data from the previous year are released. The returns of the green and brown portfolios, which are based on total emissions or emissions intensity, for the next 12 months are then given by the average return of the firms within these portfolios. This approach gives us six different variants of BMG returns.

For the simple spread BMGs, every July, we divide the firms into quintiles on the basis of their CO_2 level (intensity) from the previous year. The first quintile forms the green portfolio, whereas the last quintile forms the brown portfolio. To compute the returns on the respective portfolio, we either weight the firm-level stock returns in each portfolio equally or weight them by their market capitalization. The equally-weighted simple BMG spread is the difference between the brown and green portfolio returns that are based on equal weighting of the firms in the portfolios. However, by weighting the firms equally, we assign relatively high weights to the returns on stocks of small firms. Therefore, we also compute the value-weighted simple BMG spread that weights the returns in each portfolio by the market value of the firms.

For the size-adjusted BMG spread, we first split the companies into small and big firms on the basis of the median market value every July. Within the small and big categories, we then divide them into low, medium, and high CO_2 emission levels (intensities) from the previous year at the 30th and 70th percentiles. The returns of the resulting six portfolios are computed as the market value-weighted average return of the firms constituting them. The green portfolio returns are the equal-weighted average of the small-low and big-low averages, whereas the brown portfolio returns are computed analogously with the small-high and big-high portfolios. The size-adjusted spread is then the difference between the brown and green portfolio returns.

Table 1 reports the average total CO_2 levels (sum of scope 1 and 2 CO_2 emissions), market value, and book-to-market ratio of the BMG portfolios. Aswani et al. (2023) showed that the emission levels of a company are highly positively correlated with its size. This is also reflected in our portfolios, as brown firms have, on average, much greater market value than green firms do. The differences in market values are smaller when the CO_2 intensity is used (panel B) since it controls for size, as discussed in section 2.1. However, even when the CO_2 intensity is used, brown companies are, on average, approximately twice as large as green companies. Additionally, there are clear differences in the book-to-market ratios, which are low for brown stocks and high for green stocks. Therefore, our portfolio formation shows that CO_2 emissions and intensities of listed Swiss firms are highly correlated with variables identified in the literature as drivers of cross-sectional differences in stock returns (Fama and French, 1992).

[Table 1 about here]

We analyze the returns generated by these portfolios in Table 2. Most interestingly, in all the cases, the brown-minus-green portfolio returns are negative, meaning that the green stocks outperform the brown ones. This observation suggests that the size or the book-to-market equity ratio of a firm are more informative about firm-level stock returns in our sample than CO_2 levels (intensities) are. Small firms and firms with high book-to-market equity ratios typically offer higher returns than large firms or firms with low book-to-market equity ratios (Fama and French, 1992).

However, while the returns of the respective brown or green portfolio are statistically different from zero, their differences are not. Hence, these descriptive statistics leave the impression that there is no statistically significant carbon premium in Swiss stock returns. Appendix B additionally highlights that there is little evidence of a monotonic relationship between average portfolio returns and the CO_2 levels (intensities).

[Table 2 about here]

Figure 3 shows the cumulative logarithmic returns on the Swiss BMG portfolios throughout the sample period in the upper panel. In all the cases, the cumulative BMG portfolio return is negative at the end of our sample period, which is consistent with the current literature (Bauer et al., 2022; Pástor et al., 2022; Huij et al., 2023). Over our sample period (July 2010 to June 2024), we observe that the green portfolio outperforms the brown portfolio by 12.4% to 30.9%, depending on what portfolios we use to compute the BMG returns. This outperformance has been consistent since around 2013. We observe some temporary reversals and exceptions, such as the size-adjusted (CO_2 intensity) and equally-weighted simple spread (CO_2 intensity) between the brown and green portfolio returns, where the green portfolio does not outperform the brown portfolio until the last quarter of 2022. However, even in those two cases, we observe that the green firms outperform their brown counterparts by 14.4% and 19.9% at the end of the sample period.

The lower panel of figure 3 depicts the corresponding cumulative log BMG portfolio returns for the U.S. for comparison. The patterns of the BMG returns are similar to those reported by Bauer et al. (2022). The carbon premium in U.S. stocks is, on average, negative in our sample period. As discussed in Bauer et al. (2022), the cumulative BMG returns increased slightly in the immediate aftermath of the Russian invasion of Ukraine, but the realized cumulative BMG returns did not fully reverse their downward trend over the past ten years. Hence, the finding of a negative Swiss carbon premium is qualitatively similar to U.S. evidence.

[Figure 3 about here]

Figure 4 summarizes the same information about the Swiss BMG returns for equal- or value-weighted simple spread portfolios when the maximum number of portfolios is restricted to three (upper panel) or four (lower panel) portfolios. The qualitative pattern in the BMG returns remains the same, irrespective of the number of portfolios that we form.

[Figure 4 about here]

4 What drives brown and green stock returns?

4.1 Returns on brown and green stocks and their exposure to standard risk factors

In this section, we assess whether the carbon premium on the Swiss stock market (the return difference between stock portfolios consisting of the brown and green firms from section 3) reflects exposure to standard measures of systematic stock market risk. We use monthly data in this assessment. The sample spans July 2010 to June 2024.

We take the Fama–French three-factor model (Fama and French, 1993) as our benchmark model and run the following regression:

$$BMG_t = \alpha + \beta^{Rm\text{-}Rf} Rm\text{-}Rf_t + \beta_w^{SMB} SMB_{w,t} + \beta_w^{HML} HML_{w,t} + \varepsilon_t \qquad (2)$$

in which BMG_t denotes the carbon premium (brown-minus-green portfolio return) and $Rm\text{-}Rf_t$ represents the excess returns on the Swiss stock market. $SMB_{w,t}$ captures the size premium in returns on Swiss stocks and is defined as the return difference between the portfolios of the small firms and the big firms on the Swiss stock market as measured by their market capitalization. $HML_{w,t}$ represents the return difference between the portfolios of the Swiss firms with high and low ratios of book equity to market equity, where $t = 1, \ldots, T$ is the time subscript and $w \in \{equal, value\}$ denotes whether the firms were equally- or value-weighted while constructing $SMB_{w,t}$ and $HML_{w,t}$. We use the equally-weighted $SMB_{w,t}$ and $HML_{w,t}$ for the equally-weighted simple spread, whereas we use the value-weighted counterparts for the other four BMG portfolio returns (value-weighted simple spread and size-adjusted spread). Appendix C provides further details about the construction of the risk factors.

All of the explanatory variables are excess returns, and the dependent variable is an excess return or the return on a zero-cost portfolio. In this case, the estimate of the intercept in regression 2 can be interpreted as a risk-adjusted return (Jensen, Black, and Scholes, 1972). Hence, a significant intercept would suggest that CO_2 levels (intensities) provide information about the brown and green portfolio returns that cannot be explained by their exposure to the market return, the market-wide measure of size effects on stock returns (SMB) and the market-wide measure of book-to-market equity effects on stock returns (HML).

We focus on the three standard risk factors from Fama and French (1993) because the brown and green portfolio characteristics reveal that CO_2 levels and CO_2 intensities are strongly correlated with the size of firms and their book-to-market equity ratios in Swiss data. Therefore, we first assess whether SMB and HML describe the return dynamics of the brown-minus-green portfolio returns.

The regression results are reported in Table 3. Focusing on the first row of Table 3, we observe that the regression estimates of the intercepts are statistically indistinguishable from zero. This is true for all six variants of the BMG portfolio returns and is in line with the evidence from the U.S. presented in Appendix A1 of Bauer et al. (2022). This observation leaves the impression that the carbon premium in Swiss stock returns reflects exposures to standard measures of systematic stock market risk. There is no evidence of abnormal (risk-adjusted) BMG returns, suggesting that differences in firms' CO_2 emission levels (intensities) do not provide additional information compared with the size or book-to-market equity ratios about firms' stock returns.

For most variants of the BMG portfolio returns, the regression estimates for the market excess returns and SMB are statistically insignificant. However, the link between the carbon premium and HML is more pronounced and statistically significant. The negative HML coefficient estimates reflect that brown stocks in our sample tend to be stocks with low book-to-market value and that green stocks tend to be stocks with high book-to-market value (see Table 1). Regressing BMG returns on HML then amounts to regressing a low-minus-high book-to-market portfolio return on the market-wide high-minus-low portfolio return.

[Table 3 about here]

These results do not depend on the number of portfolios used to distinguish between brown and green stocks. Computing the simple spread BMG returns from three instead of five portfolios gives qualitatively similar results, as shown in Appendix D. The qualitative results of the assessments of the BMG returns are also robust to other checks (results available upon request), such as

- Computing CO_2 emission levels (intensities) as the sum of scope 1, scope 2 and scope 3 emissions
- Excluding the three largest firms on the Swiss stock market from our sample because those firms make up approximately 40% of the total Swiss stock market capitalization.
- Excluding one extreme firm in terms of the level of CO_2 emissions from our sample.

4.2 Climate-related news and daily variations in the Swiss carbon premium

4.2.1 Global climate change concerns

The previous section has shown that BMG returns are, on average, zero when controlling for exposures to standard risk factors. This suggests that the climate-friendliness of Swiss firms is not the most important determinant of their stock returns. Nonetheless, it could be the case that the distinction between brown and green firms matters on days of important climate-related news. In the U.S., green firms exhibit higher stock returns than brown firms do on days of unexpectedly higher climate change concerns (Ardia et al., 2023), and daily measures of the level of climate change risk appear to be associated with U.S. stock returns as well (Faccini et al., 2023). This temporary outperformance of green stocks relative to brown stocks can be rationalized with strong capital flows to environmental, social or governance (ESG) issue-themed funds in response to adverse climate news (van der Beck, 2023).

Against this background and the observation that the majority of listed Swiss firms are globally active[2], we assess whether we observe the same patterns in the Swiss carbon premium estimates as in the U.S. Therefore, we take the text-based index of climate change concerns of Ardia et al. (2023) as a stand-in for global climate change concerns. Their index (MCCC) measures the level of climate change concern in the U.S. media. We assume that U.S. media coverage represents global media coverage.

Our assessment boils down to running the following regressions for daily returns on the six variants of BMG portfolio returns introduced in section 3:

$$\begin{aligned} BMG_t = \alpha + \beta^{MCCC} MCCC_t + \beta^{Rm\text{-}Rf} Rm\text{-}Rf_t \\ + \beta_w^{SMB} SMB_{w,t} + \beta_w^{HML} HML_{w,t} + \varepsilon_t \end{aligned} \tag{3}$$

$$\begin{aligned} BMG_t = \alpha + \beta^{UMC} UMC_t + \beta^{Rm\text{-}Rf} Rm\text{-}Rf_t \\ + \beta_w^{SMB} SMB_{w,t} + \beta_w^{HML} HML_{w,t} + \varepsilon_t \end{aligned} \tag{4}$$

where $MCCC_t$ and UMC_t are the Media Climate Change Concerns index and its unexpected component, respectively, as defined in section 2.2. The other variables are the same as those in equation 2 but at a daily frequency. The results of both regressions are reported in Table 4.

The regression estimates presented in Table 4 are quickly summarized. Panel A of Table 4 reveals that for one definition of BMG returns (size-adjusted spread), there is a statistically significant association between the level of the climate change concern index and the BMG returns. BMG returns decline when climate change concerns are high. This finding is in line with Ardia et al. (2023) and Berthold (2024). However, it does not pertain to the other four variants of BMG returns.

[2]Estimates for the 20 largest listed Swiss firms (comprising approximately 80% of the total Swiss stock market capitalization) suggest that approximately 90% of their revenues are generated abroad (Rasch, 2015).

MCCC might be correlated with other variables, e.g., oil or other commodity prices, that potentially affect stock market investors' risk-return considerations but do not necessarily reflect investors' climate change concerns. This is why Ardia et al. (2023) suggested focusing on the unexpected component of their climate change concerns index, UMC_t. We do the same in this paper. Panel B of Table 4 highlights that there is no significant association between the unexpected part of the climate change concerns index and the BMG returns. Controlling for the three Fama–French risk factors, the coefficients on UMC are statistically indistinguishable from zero.

We repeated this regression exercise, focusing on realizations of MCCC and UMC larger than their 75% and 90% percentiles, respectively. Moreover, we repeated the regressions with monthly data. In all of these cases, we find qualitatively similar results as reported above. These results are available upon request.

[Table 4 about here]

Taken together, these regression results suggest that the links of BMG returns to either the level of the MCCC or the unexpected changes in the MCCC (UMC) are weak. These results are qualitatively in line with those of Arteaga Garavito, Colacito, Croce, and Yang (2025), who found that returns on brown firms from countries with relatively little exposure to global climate news shocks, such as Switzerland, do not respond to global climate news.

4.2.2 Transition risks and the Swiss carbon premium

Ardia et al. (2023) and Berthold (2024) found that returns on green stocks increase relative to returns on brown stocks with the arrival of news about increasing transition risks. We assess whether these findings hold in the context of our paper.

We focus on events related to so-called transition risks, i.e., risks associated with the politically intended transition from a carbon-intensive economy to a carbon-light economy. Here, we rely on the work of Berthold (2024), who identified important transition risk events as local maxima of his Swiss climate policy risk index. We work with all 21 events reported in Table 1 in Berthold (2024), which occurred in our sample period from July 2010 to June 2024.

Using the classification of Berthold (2024), one can distinguish between domestic (*dom*) and international (*int*) transition risk events. The domestic events are an IEA report in favor of a CO_2 tax in Switzerland (*dom.iea*), a pledge of the federal government to fund the UN Green Fund (*dom.fc*), official support by the liberal Swiss party (FDP) for the Paris Climate Agreement (*dom.fdppca*), the proposal of a plane ticket tax (*dom.planetax*), the acceptance of a revised Federal Energy Act by the Swiss electorate (*dom.fea*), the publication of a report highlighting the need to invest in infrastructure (*dom.infra*), the day of the Swiss Federal Election in 2019 in which green parties strongly increased their numbers of members of parliament (*dom.green*), a warning of the Federal Environment Office of climate risks (*dom.feo*), the Swiss financial market authority (FINMA) publishing transparency obligations for climate risks (*dom.finma*), the codification of climate neutrality by 2050 by voters in the canton of Bern (*dom.bern*) and the publication of a plan for a revised Swiss CO_2 law (*dom.co2law*). The international events include three publications of IPCC reports (*int.ipcc*), the election of a right-wing government in Austria (*int.aut*), the election of Joe Biden as president of the USA (*int.biden*), the publication of stricter climate goals by the EU in 2020 (*int.eu*), Nobel Prize winners calling for actions against climate change in 2021 (*int.nobel*), the EU Commission publishing a plan to reduce CO_2 (*int.ec*) and the G20 meeting in Rome in 2021 (*int.g20*). Berthold (2024) classified Switzerland's decision to ratify the Paris Climate Agreement (*domint.paris*) as both domestic and international.

Our empirical assessment takes the form of an event study regression for each of our six BMG returns at the daily frequency, i.e.,

$$\begin{aligned} BMG_t = \alpha + \sum_e \left(\beta_e d_{e,t} + \beta_e^b d_{e,t-1} + \beta_e^a d_{e,t+1}\right) \\ + \beta^{Rm\text{-}Rf} Rm\text{-}Rf_t + \beta_w^{SMB} SMB_{w,t} + \beta_w^{HML} HML_{w,t} + \varepsilon_t \end{aligned} \quad (5)$$

in which $d_{e,t}$ denotes a dummy variable taking a value of one on the day of event e and zero otherwise, whereas $d_{e,t-1}$ and $d_{e,t+1}$ denote dummies taking values of one on the working day before and after event e, respectively, and zero otherwise. The regression estimates of d are interpretable as abnormal or risk-adjusted returns (Gibbons, 1980; Salinger, 1992). The other variables are defined as in equation 2.

It is important to note that we focus on events of high transition risks (local maxima of a climate policy risk index). Hence, we expect negative coefficient estimates of the event dummies, i.e., evidence that green firms outperform brown firms on days of high transition risks.

Table 5 reports the event study results. In those cases in which the event occurred on a weekend or holiday, we can report only the coefficient estimates of the dummies of the working day before or after the event.

When we control for the Fama–French risk factors, most of the transition risk events are not associated with the Swiss carbon premium. In the majority of cases, the point estimates of the dummy regression coefficients are indistinguishable from zero.

No event affected the majority of the six BMG return variants under study, but three events significantly affected three of the six BMG return variants. The first of these events is the day after the Swiss electorate voted in favor of a (revised) Federal Energy Act in May 2017. The Federal Energy Act promoted renewable sources of energy and set targets to reduce energy consumption. The regression estimates for the corresponding dummy variable $dom.fea.a1$ for the working day after this vote are positive and significant for three of the six BMG return definitions. This means that the BMG returns were higher on the working day following this event. At first glance, this observation seems to be at odds with the general finding of previous studies (Ardia et al., 2023; Berthold, 2024) that news about higher transition risks increases the returns on green stocks relative to the returns on brown stocks. However, this event might have been special in the sense that polls in April 2017 suggested that a clear majority of Swiss voters favor the approval of the Federal Energy Act (Pauchard, 2017). Hence, the final approval of the Federal Energy Act in May 2017 was not news to investors. The signs of the dummy coefficients for the two other events that affected three of the six BMG return variants are in line with earlier evidence (Ardia et al., 2023; Berthold, 2024). The election of Joe Biden as president of the United States of America in November 2020 (*int.biden*) is associated with negative abnormal returns, as is the publication of an IPCC report in April 2022 (*int.ipcc*3).

There are few events for which we find a significant association between the event and at least some of the six different BMG returns that we analyze. Hence, these event study results suggest that the link between the Swiss carbon premium and transition risk events is weak.

[Table 5 about here]

4.3 Evidence from panel regressions

This section assesses the link between Swiss stock returns and CO_2 levels (intensities) in (unbalanced) panel regressions to check the robustness of our results on the basis of portfolio methods, i.e., allocating stocks into portfolios on the basis of their CO_2 levels (intensities). The regression setup follows Zhang (2024) as closely as possible with Swiss data. It takes the form of unbalanced panel regressions of monthly firm-level (i) stock returns observed in month t on the CO_2 level (intensity) of firm i and a range of controls observed in month $t-1$ and time fixed effects, i.e.,

$$r_{it} = \alpha + \beta^{emissions} Emissions_{i,t-1} + \beta^{controls} Controls_{i,t-1} + \eta_t + \epsilon_{it} \tag{6}$$

Table 6 reports the results. The t-statistics reflect standard errors clustered at the firm and month levels. In addition, the specifications in Columns 2 and 4 control for industry fixed effects.[3] The CO_2 levels or CO_2 intensities are standardized to have unit variance and a zero mean. In addition, we still control for the publication lag in the CO_2 data. Appendix E provides the details about the control variables.

We are primarily interested in estimates of $\beta^{emissions}$ from regression 6. These estimates are consistently negative in the regression specifications presented in Table 6. This evidence suggests that high (low) CO_2 levels are associated with low (high) stock returns at the firm level. However, the point estimates tend to be statistically insignificant, which corroborates our main findings based on the portfolios sorted by firms' CO_2 levels (intensities). Interestingly, the results for CO_2 intensities suggest that the negative link between CO_2 intensities and firm-level stock returns is weakly statistically significant. These regression results are robust to excluding one extreme firm in terms of its CO_2 emissions levels or the three largest firms in the Swiss stock market that make up approximately 40% of the total Swiss stock market capitalization. These results are not reported but are available upon request.

Moreover, the signs of the coefficients on size and the book-to-market equity

[3]These results are based on the industry classification provided by LSEG Datastream. In our sample, there are 18 different industrial sectors

ratio reveal the typical link between firm-level stock returns and these characteristics (Fama and French, 1992) even though they are statistically insignificant in this setting. Small firms tend to offer higher returns than large firms do, which explains the negative regression coefficient. Firms with high book-to-market equity tend to offer higher returns than firms with low book-to-market equity do, which is reflected in the positive regression coefficient for BM.

[Table 6 about here]

5 Conclusions

This paper assessed whether investors in Swiss stocks require extra compensation for investing in firms with high carbon emissions (brown) relative to firms with low carbon emissions (green). Our empirical results suggest that this is not the case. Other characteristics, such as size or the ratio of book equity to market equity, are more important determinants of Swiss firms' stock returns. Consequently, standard measures of systematic stock market risk provide an adequate description of the Swiss carbon premium, i.e., the return difference between portfolios consisting of stocks from brown and green firms. This finding pertains to six different variants of computing the brown and green stock portfolios. Panel regressions corroborate the main results of the assessments based on portfolio methods. In addition, our empirical analyses show that the Swiss carbon premium rarely responds to climate news or events associated with the transition to a greener economy.

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Tables

Table 1: Descriptive Statistics of the Portfolio Data

Panel A: Portfolios based on CO_2 Level

	Size-Adjusted Spread		Simple Spread	
	Brown	Green	Brown	Green
Total CO_2 (tonnes, 1-year lag)	8256454.24	13030.00	12294289.13	2925.34
Market Value	45139.79	8972.79	72084.09	4677.42
Book-to-Market	0.46	0.99	0.38	1.26

Panel B: Portfolios based on CO_2 Intensity

	Size-Adjusted Spread		Simple Spread	
	Brown	Green	Brown	Green
Total CO_2 (tonnes, 1-year lag)	8139568.42	25167.06	11964495.91	11170.87
Market Value	24996.02	13502.53	26538.10	12104.21
Book-to-Market	0.50	1.10	0.53	1.33

Notes: This table provides characteristics (total CO_2 emissions, market value and book-to-market equity ratio) of the portfolios underlying the computation of the carbon premium, i.e. the return difference between brown and green stock portfolios. Size-adjusted spread means that firms were allocated to portfolios dependent on their size and CO_2 level or CO_2 intensity. Simple spread means that firms are allocated into portfolios based only on CO_2 emissions (level or intensity). The sample period spans July 2010 to June 2024.

Table 2: Descriptive Statistics of the Portfolio Returns

Panel A: Portfolios based on CO_2 Level

	Size-Adjusted Spread			V.W. Simple Spread			E.W. Simple Spread		
	Brown	Green	BMG	Green	Brown	BMG	Green	Brown	BMG
Mean	0.0098	0.0129	-0.0031	0.0120	0.0085	-0.0034	0.0081	0.0070	-0.0011
T-Statistic	3.2232	4.0927	-1.6436	3.2707	3.2099	-1.1251	2.2808	2.0139	-0.4409
Sharpe Ratio	0.2530	0.3200	-0.1197	0.2560	0.2527	-0.0825	0.1797	0.1592	-0.0288

Panel B: Portfolios based on CO_2 Intensity

	Size-Adjusted Spread			V.W. Simple Spread			E.W. Simple Spread		
	Brown	Green	BMG	Green	Brown	BMG	Green	Brown	BMG
Mean	0.0093	0.0108	-0.0015	0.0117	0.0092	-0.0026	0.0096	0.0077	-0.0020
T-Statistic	2.8829	2.9905	-0.6082	3.2905	2.9289	-0.8218	2.8292	1.8045	-0.6634
Sharpe Ratio	0.2265	0.2344	-0.0415	0.2576	0.2302	-0.0591	0.2222	0.1423	-0.0467

Notes: This table provides mean returns, their t-statistics and the Sharpe Ratio on portfolios of brown and green portfolios and their return differences (BMG). It distinguishes between three ways to build the portfolios and whether to use CO_2 levels or CO_2 intensity to distinguish between brown and green firms. Size-adjusted spread means that firms were allocated to portfolios dependent on their size and CO_2 emissions (level or intensity). Simple spread means that firms are allocated into portfolios based only on CO_2 emissions (level or intensity). Firms' stock returns are either value-weighted (V.W.) or equal-weighted (E.W.) to compute the portfolio returns. The sample period spans July 2010 to June 2024.

Table 3: Fama-French 3-Factor Model

	Size-Adjusted Spread		V.W. Simple Spead		E.W. Simple Spead	
	(CO_2 Level)	(CO_2 Int.)	(CO_2 Level)	(CO_2 Int.)	(CO_2 Level)	(CO_2 Int.)
Intercept	-0.0029	-0.0007	-0.0021	-0.0008	-0.0005	-0.0023
	(0.0019)	(0.0024)	(0.0032)	(0.0031)	(0.0026)	(0.0032)
Rm-Rf	0.0843	0.0953	0.0362	0.0320	0.0876	0.1713*
	(0.0561)	(0.0718)	(0.0921)	(0.1021)	(0.0748)	(0.1018)
SMB (v.w.)	0.0583**	0.1610**	0.1020	0.1256		
	(0.0258)	(0.0643)	(0.0913)	(0.0923)		
HML (v.w.)	-0.1131***	-0.2345***	-0.2327*	-0.2914**		
	(0.0398)	(0.0781)	(0.1204)	(0.1347)		
SMB (e.w.)					-0.0348	-0.1619
					(0.1040)	(0.1317)
HML (e.w.)					-0.1895**	-0.1673
					(0.0905)	(0.1060)
R^2	0.0572	0.1388	0.0605	0.0896	0.0535	0.0717
Adj. R^2	0.0399	0.1230	0.0433	0.0729	0.0362	0.0547
Observations	168	168	168	168	168	168

Notes: This table provides estimates from regressing each of the six variants of the carbon premium (BMG) in Swiss stock returns on the risk factors of the Fama-French three-factor model. The factors are the market return (Rm-Rf), the return difference between portfolios of small and big firms (SMB) and the return difference between portfolios firms with high and low book-to-market equity ratios (HML). *, ** and *** denote statistical significance at the 10%, 5% and 1% level respectively. The data frequency is monthly. The sample period spans July 2010 to June 2024.

Table 4: Fama–French 3-Factor Model with the MCCC and UMC

Panel A: MCCC

	Size-Adjusted Spread		V.W. Simple Spead		E.W. Simple Spead	
	(CO_2 Level)	(CO_2 Int.)	(CO_2 Level)	(CO_2 Int.)	(CO_2 Level)	(CO_2 Int.)
Intercept	-0.0000	0.0004	-0.0003	0.0001	-0.0002	0.0002
MCCC	-0.0002	-0.0005**	0.0001	-0.0003	0.0001	-0.0004
Rm-Rf	0.1417***	0.1968***	0.2557***	0.2810***	0.1585***	0.0603**
SMB (v.w.)	0.2235***	0.4484***	0.4472***	0.5787***		
HML (v.w.)	-0.1598***	-0.3177***	-0.3369***	-0.4184***		
SMB (e.w.)					0.0869***	0.0546***
HML (e.w.)					-0.0517***	-0.0350***
R^2	0.0700	0.2316	0.1377	0.2183	0.0326	0.0059
Adj. R^2	0.0689	0.2308	0.1367	0.2175	0.0315	0.0048
Observations	3516	3516	3516	3516	3516	3516

Panel B: UMC

	Size-Adjusted Spread		V.W. Simple Spead		E.W. Simple Spead	
	(CO_2 Level)	(CO_2 Int.)	(CO_2 Level)	(CO_2 Int.)	(CO_2 Level)	(CO_2 Int.)
Intercept	-0.0002	-0.0001	-0.0002	-0.0002	-0.0001	-0.0002
UMC	0.0002	-0.0001	-0.0001	0.0000	0.0003	0.0002
Rm-Rf	0.1297***	0.1939***	0.2585***	0.2694***	0.1299***	0.0085
SMB (v.w.)	0.2118***	0.4360***	0.4287***	0.5149***		
HML (v.w.)	-0.1515***	-0.3086***	-0.3184***	-0.3720***		
SMB (e.w.)					0.0752***	0.0501***
HML (e.w.)					-0.0445***	-0.0313**
R^2	0.0654	0.2354	0.1230	0.1845	0.0239	0.0029
Adj. R^2	0.0639	0.2342	0.1217	0.1833	0.0224	0.0014
Observations	2624	2624	2624	2624	2624	2624

This table provides estimates from regressing each of the six variants of the carbon premium (BMG) in Swiss stock returns on the risk factors of the Fama-French three-factor model and the level of a US climate change concern index (MCCC) in panel A and on the unexpected change in the climate change concern index (UMC) in panel B. The risk factors are the market return (Rm-Rf), the return difference between portfolios of small and big firms (SMB) and the return difference between portfolios of firms with high and low book-to-market equity ratios (HML). The climate change concern index is from Ardia et al. (2023) and the computation of the unexpected component of a change in this index follows their approach. *, ** and *** denote statistical significance at the 10%, 5% and 1% level respectively. The data frequency is labor daily. The sample period spans July 2010 to June 2024. For the UMC regression, the sample begins in February 2013 due to data restrictions among the controls used in equation 1.

Table 5: Transition Risk Event Study

	Size-Adjusted Spread		V.W. Simple Spread		E.W. Simple Spread	
	(CO_2 Level)	(CO_2 Int.)	(CO_2 Level)	(CO_2 Int.)	(CO_2 Level)	(CO_2 Int.)
(Intercept)	-0.0002*	-0.0001	-0.0002	-0.0001	-0.0001	-0.0001
Market	0.1432***	0.2013***	0.2620***	0.2846***	0.1567***	0.0601***
SMB	0.2251***	0.4562***	0.4534***	0.5859***		
HML	-0.1603***	-0.3224***	-0.3409***	-0.4225***		
dom.iea.b1	0.0020	0.0047	0.0050	0.0039	0.0037	0.0092
dom.iea	0.0003	0.0109*	0.0007	0.0053	0.0099	0.0155**
dom.iea.a1	0.0029	-0.0016	-0.0014	-0.0040	0.0018	-0.0031
dom.fc.b1	0.0012	0.0016	-0.0028	-0.0014	-0.0005	-0.0003
dom.fc	-0.0032	-0.0056	0.0032	-0.0005	0.0001	-0.0021
dom.fc.a1	-0.0010	-0.0002	0.0038	0.0041	0.0011	-0.0011
dom.fea.b1	-0.0027	0.0080	0.0013	0.0078	-0.0006	0.0022
dom.fea.a1	0.0091	0.0147**	0.0102	0.0144*	0.0123*	0.0117
domint.paris.b1	-0.0039	-0.0028	-0.0035	-0.0058	-0.0049	-0.0043
domint.paris	0.0032	0.0014	0.0084	0.0010	0.0038	0.0010
domint.paris.a1	0.0051	0.0044	0.0000	0.0040	0.0061	0.0104
dom.fdppca.b1	-0.0052	0.0011	-0.0038	-0.0068	-0.0069	-0.0036
dom.fdppca.a1	-0.0035	-0.0021	-0.0028	-0.0058	0.0020	-0.0057
dom.planetax.b1	0.0013	0.0027	0.0091	0.0053	0.0068	-0.0015
dom.planetax	0.0018	0.0019	-0.0003	0.0004	0.0003	0.0004
dom.planetax.a1	0.0039	0.0054	-0.0002	0.0066	0.0017	0.0030
int.ipcc.b1	-0.0022	0.0003	-0.0019	-0.0025	-0.0126*	-0.0050
int.ipcc	-0.0027	-0.0059	-0.0052	-0.0095	0.0007	-0.0007
int.ipcc.a1	-0.0043	-0.0049	-0.0006	-0.0080	-0.0007	-0.0016
dom.infra.b1	0.0019	0.0049	-0.0005	0.0041	0.0003	0.0058
dom.infra	0.0060	0.0034	0.0000	0.0068	0.0070	0.0041
dom.infra.a1	0.0025	0.0003	-0.0158**	0.0106	-0.0105	-0.0025
dom.green.b1	0.0043	-0.0013	0.0108	-0.0014	0.0052	0.0006
dom.green.a1	0.0079	0.0047	-0.0003	0.0110	0.0086	0.0140*
int.aut.b1	-0.0022	-0.0022	0.0068	-0.0058	-0.0043	-0.0104
int.aut.a1	0.0017	0.0015	0.0023	-0.0023	-0.0027	-0.0006
int.biden.b1	0.0000	-0.0003	-0.0027	-0.0028	-0.0026	0.0060
int.biden.a1	-0.0247***	-0.0019	-0.0119	-0.0152*	-0.0179**	-0.0010
int.eu.b1	0.0055	0.0023	0.0030	-0.0039	0.0053	-0.0022
int.eu	0.0030	0.0055	0.0013	0.0133*	0.0040	0.0040
int.eu.a1	0.0051	0.0046	0.0043	0.0005	0.0061	0.0055
dom.feo.b1	-0.0046	-0.0093	0.0002	-0.0057	-0.0112	-0.0025

	Size-Adjusted Spread		V.W. Simple Spread		E.W. Simple Spread	
	(CO_2 Level)	(CO_2 Int.)	(CO_2 Level)	(CO_2 Int.)	(CO_2 Level)	(CO_2 Int.)
dom.feo	-0.0051	-0.0032	-0.0117	-0.0021	-0.0077	-0.0066
dom.feo.a1	0.0037	0.0015	0.0078	0.0079	-0.0018	0.0024
dom.finma.b1	-0.0033	-0.0018	-0.0097	-0.0073	0.0058	0.0019
dom.finma	-0.0045	0.0009	-0.0074	-0.0018	0.0012	0.0049
dom.finma.a1	0.0017	0.0009	0.0016	-0.0037	0.0028	0.0046
int.nobel.b1	0.0012	-0.0019	0.0049	0.0005	0.0055	0.0010
int.nobel	-0.0035	0.0007	-0.0024	0.0030	-0.0004	0.0031
int.nobel.a1	-0.0000	0.0011	0.0103	0.0075	0.0008	-0.0063
int.ec.b1	-0.0059	-0.0015	-0.0062	-0.0041	-0.0014	-0.0062
int.ec	0.0049	0.0051	0.0055	0.0049	0.0031	0.0092
int.ec.a1	0.0007	0.0015	0.0019	0.0021	-0.0013	-0.0023
int.ipcc2.b1	-0.0001	-0.0026	0.0045	-0.0005	0.0010	-0.0036
int.ipcc2	0.0014	-0.0039	0.0053	-0.0017	-0.0029	-0.0108
int.ipcc2.a1	0.0047	-0.0044	0.0011	-0.0006	0.0014	0.0016
dom.bern.b1	0.0054	0.0057	0.0077	0.0017	-0.0110	0.0009
dom.bern.a1	0.0052	-0.0024	0.0082	-0.0097	-0.0060	-0.0002
int.g20.b1	0.0008	0.0044	0.0036	0.0009	-0.0006	-0.0051
int.g20.a1	0.0083	0.0043	0.0091	0.0059	0.0096	0.0063
int.ipcc3.b1	-0.0003	0.0029	0.0128	0.0068	0.0024	-0.0004
int.ipcc3	0.0035	0.0118**	-0.0041	0.0094	-0.0032	0.0024
int.ipcc3.a1	-0.0058	-0.0145**	-0.0132*	-0.0160**	-0.0001	-0.0070
dom.co2law.b1	-0.0056	-0.0107*	0.0055	-0.0035	-0.0047	-0.0097
dom.co2law	-0.0037	0.0008	0.0034	0.0019	-0.0117	0.0043
dom.co2law.a1	0.0033	-0.0029	0.0011	-0.0020	0.0047	-0.0079
SMBew					0.0849***	0.0565***
HMLew					-0.0503***	-0.0361***
R^2	0.0828	0.2394	0.1462	0.2265	0.0431	0.0152
Adj. R^2	0.0671	0.2264	0.1316	0.2133	0.0268	-0.0016
Num. obs.	3516	3516	3516	3516	3516	3516

This table provides estimates from regressing each of the six variants of the carbon premium (BMG) in Swiss stock returns on the risk factors of the Fama–French three-factor model and dummies that take values of one on event days and zero otherwise. The 21 events are from Table 1 in Berthold (2024), who distinguished between domestic (*dom.*) and international (*int.*) events. In addition, we include dummies for the day before the event (*.b*) and the day after the event (*.a*). The data frequency is daily. The events are described in the main text. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The sample spans July 2010 to June 2024.

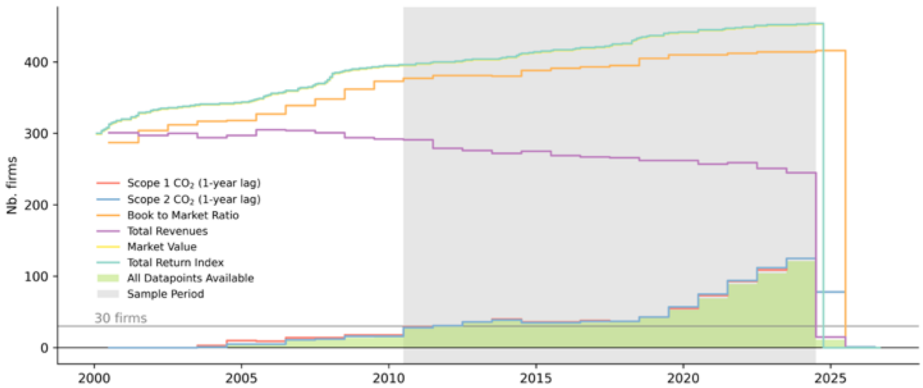
Table 6: Stock returns and CO2 emissions: panel regressions

Dependent Variable:	firm-level stock return			
CO_2	levels		intensity	
Model:	(1)	(2)	(3)	(4)
Variables				
CO_2 levels	-0.0006	-0.0005		
	(-0.6726)	(-0.6238)		
CO_2 intensity			-0.0011	-0.0018*
			(-1.542)	(-1.938)
$r_{i,t-1}$	-0.0152	-0.0169	-0.0145	-0.0165
	(-0.5620)	(-0.6222)	(-0.5378)	(-0.6075)
size	-0.0005	-0.0004	-0.0016	-0.0015
	(-0.4076)	(-0.2985)	(-1.193)	(-0.9770)
book-to-market	0.0035	0.0043	0.0027	0.0045
	(1.546)	(1.484)	(1.193)	(1.590)
momentum	-0.0068	-0.0067	-0.0062	-0.0063
	(-0.9657)	(-0.9417)	(-0.8856)	(-0.8809)
beta	0.0008	-0.0004	0.0016	-0.0002
	(0.2022)	(-0.1053)	(0.4239)	(-0.0671)
oil_exp	-0.0102	-0.0065	-0.0117	-0.0094
	(-0.6703)	(-0.4130)	(-0.7743)	(-0.5938)
gas_exp	-0.0298**	-0.0364***	-0.0322***	-0.0393***
	(-2.577)	(-2.657)	(-2.837)	(-2.995)
com_exp	0.0032	0.0030	0.0036	0.0041
	(0.4781)	(0.4359)	(0.5393)	(0.5847)
asset growth	0.0003***	0.0003***	0.0003***	0.0003***
	(4.391)	(4.071)	(4.232)	(4.048)
leverage	-0.0171**	-0.0194***	-0.0169**	-0.0172**
	(-2.446)	(-2.694)	(-2.525)	(-2.516)
ppe	0.0016	0.0015	0.0029**	0.0030*
	(1.638)	(1.231)	(2.045)	(1.807)
sales growth	0.0152***	0.0146***	0.0144***	0.0140***
	(3.974)	(3.434)	(3.559)	(3.195)
eps growth	-0.0007	-0.0008	-0.0008	-0.0009
	(-0.1309)	(-0.1574)	(-0.1631)	(-0.1798)
roa	0.0880***	0.0909***	0.0907***	0.0948***
	(4.557)	(4.024)	(4.730)	(4.131)
Fixed-effects				
time	Yes	Yes	Yes	Yes
industry		Yes		Yes
Observations	8,596	8,596	8,596	8,596
R^2	0.29961	0.30086	0.29995	0.30129

Notes: This table presents estimates from regressions of firm-level stock returns observed in month t on the CO_2 level (intensity) of firm i and a range of controls observed in month $t-1$ and time fixed effects. The t-statistics in parentheses reflect standard errors clustered at the firm and month levels. In addition, the specifications in Columns 2 and 4 control for industry fixed effects. The emissions variables (log levels or emissions intensity) are standardized to have unit variance and a zero mean. The controls are the lagged (by one month) firm-level stock returns, firm-level momentum returns (past returns from $t-12$ to $t-2$), the exposures to the Swiss market return (beta) and to oil, gas and commodity index returns computed from 60-month rolling window regressions, size (log market capitalization), log book-to-market ratio, growth in earnings per share (eps growth), growth in total assets (assets growth), log property plant and equipment (ppe), sales growth and leverage (debt divided by total assets). *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The data frequency is monthly. The sample period spans July 2010 to June 2024.

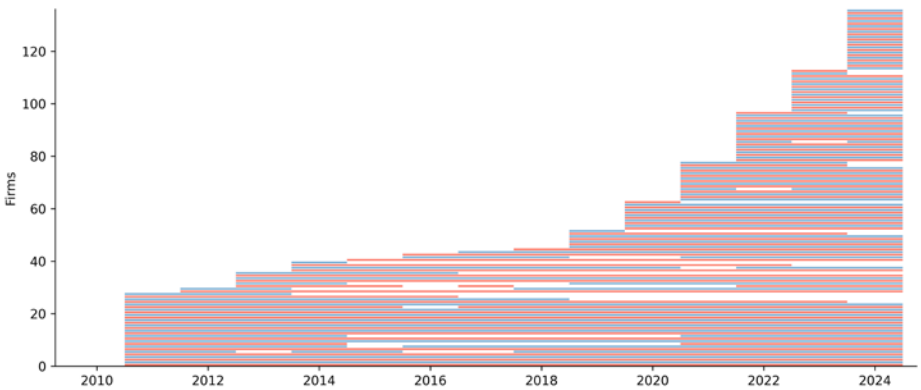
Figures

Figure 1: Firm-data Availability



Notes: This figure presents an overview of how the data availability for the empirical analyses of this paper evolved over time. We focus on CO_2 levels (intensity) and other characteristics of listed Swiss firms. The gray area indicates our sample period from July 2010 to June 2024. The green area shows for how many firms all necessary data became available over time.

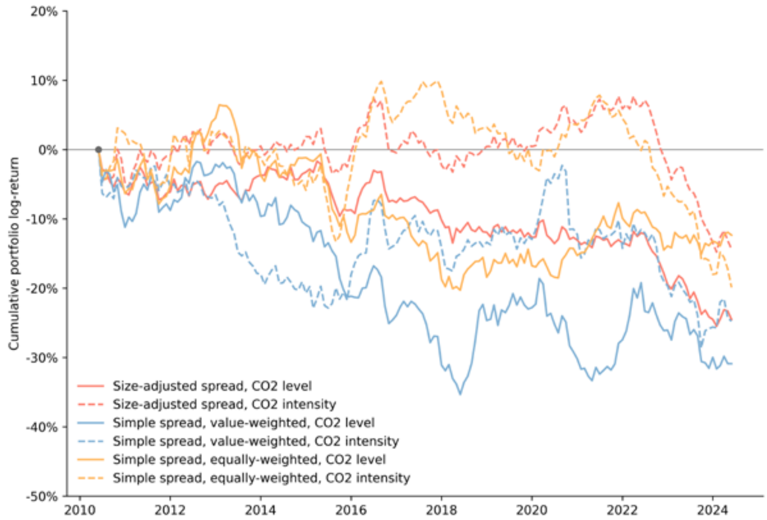
Figure 2: Sample Years per Firm



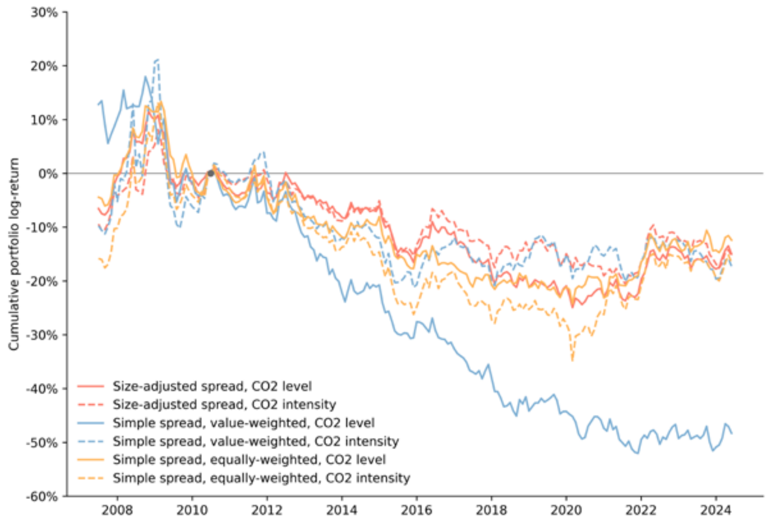
Notes: This figure depicts the number of Swiss listed firms over the years of our sample and the time these firms stay in the sample.

Figure 3: Brown-Minus-Green Portfolio Returns

(a) ***Switzerland***



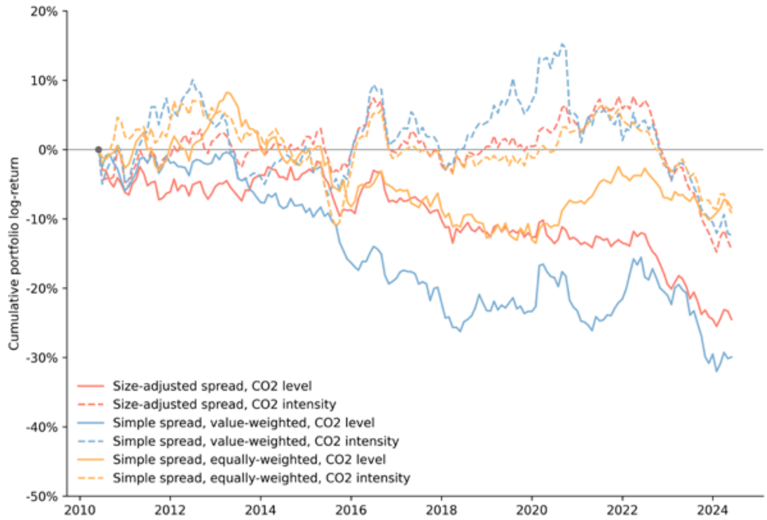
(b) ***U.S.***



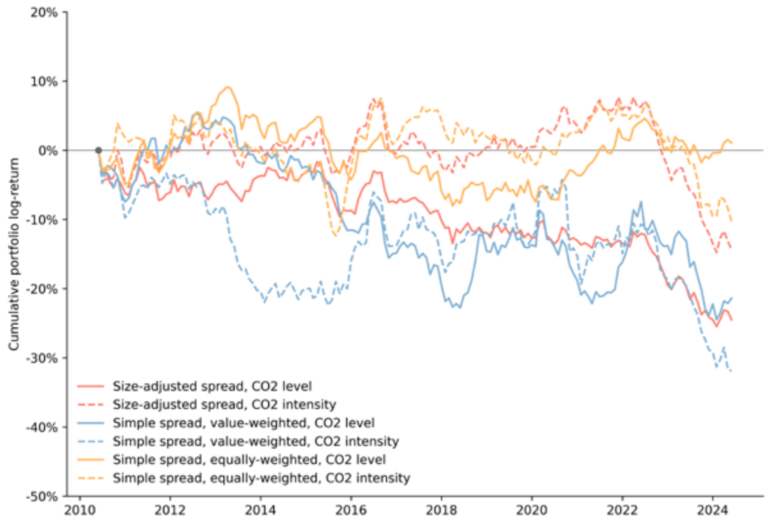
Notes: This figure depicts the cumulative log carbon premium (brown-minus-green portfolio returns) for six variants of brown and green stock portfolios (Bauer et al., 2022). The upper panel presents the results for Switzerland. The lower panel shows the results for the USA for comparison. The black dot indicates the start of the Swiss data sample.

Figure 4: Brown-Minus-Green Portfolio Returns

(a) ***Switzerland: Three portfolios for simple spread***



(b) ***Switzerland: Four portfolios for simple spread***



Notes: This figure depicts the cumulative log carbon premium (brown-minus-green portfolio returns) for six variants of brown and green stock portfolios (Bauer et al., 2022) comprising

Swiss firms. The upper panel presents the results when we use three portfolio to compute simple spread BMG returns. The lower panel shows the corresponding results when we use four portfolios to compute simple spread BMG returns. The black dot indicates the start of the Swiss data sample.

Appendices

A Control variables for computing the UMC

Following Ardia et al. (2023), we use the following variables as controls to compute the unexpected part of the media climate change concern index, namely, the UMC:

- Fama and French (2015)'s five risk factors (excess market returns, high-minus-low, small-minus-big, conservative-minus-aggressive, robust-minus-weak) for the U.S.
- Carhart (1997) momentum factor for the U.S.
- Crude oil returns computed using data from FRED[4]
- Natural gas returns computed using data from FRED[5]
- Propane returns computed using data from FRED[6]
- Economic Policy Uncertainty Index computed using data from FRED[7]
- CBOE Volatility Index computed using data from FRED[8]
- Fung and Hsieh (2004)'s term and default factors for the U.S. replicated using data from FRED[9][10]

[4]U.S. Energy Information Administration, Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma [DCOILWTICO], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/DCOILWTICO, July 8, 2024.

[5]U.S. Energy Information Administration, Henry Hub Natural Gas Spot Price [DHHNGSP], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/DHHNGSP, July 8, 2024.

[6]U.S. Energy Information Administration, Propane Prices: Mont Belvieu, Texas [DPROPANEMBTX], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/DPROPANEMBTX, July 8, 2024.

[7]Baker, Scott R., Bloom, Nick and Davis, Stephen J., Economic Policy Uncertainty Index for United States [USEPUINDXD], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/USEPUINDXD, July 8, 2024.

[8]Chicago Board Options Exchange, CBOE Volatility Index: VIX [VIXCLS], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/VIXCLS, July 8, 2024.

[9]Moody's, Moody's Seasoned Baa Corporate Bond Yield [BAA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/BAA, July 8, 2024.

[10]Board of Governors of the Federal Reserve System (U.S.), Market Yield on U.S. Treasury

- S&P's green bond index from LSEG Datastream (SPGRBND)
- Green-minus-brown portfolio returns computed for the U.S. with the same methodology we used for Switzerland (see figure 3)

Securities at 10-Year Constant Maturity, Quoted on an Investment Basis [GS10], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/GS10, July 8, 2024.

B Descriptive statistics of the portfolio returns

If stock returns and CO_2 levels (intensities) are linked, one would expect a monotonic relationship between the CO_2 levels (intensities) and average returns on the portfolios sorted by the level or intensity of CO_2 emissions.

Table B.1 summarizes this relationship for the five portfolios that underlie the simple-spread BMG returns. Panel A presents the results for the portfolios in which the firm-level returns within each portfolio receive equal weight. Panel B presents the corresponding results for the portfolios in which the firm-level returns within each portfolio receive weights on the basis of their market capitalization. In both panels, we additionally distinguish between the portfolios formed according to firms' CO_2 emission levels and CO_2 emission intensities.

The results are easily summarized. Individually, the portfolio returns sorted by CO_2 levels (intensities) are significantly different from zero. However, the relationship between the average portfolio returns and CO_2 levels (intensities) is not monotonic. There is neither evidence that portfolio returns monotonically increase nor decrease with increasing CO_2 emission levels or intensities.

Table B.1: Descriptive Statistics of the Simple Spread Quintile Returns

Panel A: Equally-Weighted Simple Spread

Quintile	CO_2 Level			CO_2 Intensity		
	Mean	T-Statistic	Sharpe Ratio	Mean	T-Statistic	Sharpe Ratio
1 (green)	0.0081	2.2808	0.1797	0.0096	2.8292	0.2222
2	0.0094	2.6462	0.2079	0.0043	1.1304	0.0907
3	0.0067	1.7979	0.1423	0.0111	3.2794	0.2569
4	0.0098	2.7252	0.2139	0.0081	2.6231	0.2067
5 (brown)	0.0070	2.0139	0.1592	0.0077	1.8045	0.1423

Panel B: Value-Weighted Simple Spread

Quintile	CO_2 Level			CO_2 Intensity		
	Mean	T-Statistic	Sharpe Ratio	Mean	T-Statistic	Sharpe Ratio
1 (green)	0.0120	3.2707	0.2560	0.0117	3.2905	0.2576
2	0.0137	4.2318	0.3306	0.0069	1.7071	0.1350
3	0.0079	2.0119	0.1586	0.0099	3.3088	0.2597
4	0.0101	2.7691	0.2173	0.0086	2.6880	0.2116
5 (brown)	0.0085	3.2099	0.2527	0.0092	2.9289	0.2302

Notes: This table provides mean returns, their t-statistics and the Sharpe Ratio on portfolios sorted by CO_2 levels or CO_2 intensity. Firms' stock returns are either equal-weighted (Panel A) or value-weighted (Panel B) to compute the portfolio returns. The sample period spans July 2010 to June 2024.

C Stock market risk factors

The descriptive statistics of the brown and green portfolios leave the impression that CO_2 levels and CO_2 intensities are correlated with size and the ratio of book equity to market equity. These two characteristics are important determinants of firm-level stock returns (Fama and French, 1992). The three-factor model proposed by Fama and French (1993) introduces two variables that capture size effects and the effects of book-to-market equity on firm-level stock returns. Hence, we use the Fama and French (1993) model to evaluate whether the brown-minus-green portfolio returns exhibit significant exposure to measures of systematic stock market risk. To do so, we compute the excess market returns (Rm-Rf), small-minus-big portfolio returns (SMB) and high-minus-low book-to-market portfolio returns (HML) with our Swiss company data.

First, we compute the Rm-Rf as the difference between the returns on the Swiss Performance Index (SWSPIXD) from Datastream and the SARON. The Swiss Performance Index (SPI) comprises basically all listed Swiss companies and is a total return index that assumes that dividends are reinvested. Our proxy of the risk-free rate (Rf) is the SARON. The SARON is a secured, short-term (overnight) Swiss franc (CHF) money market rate and the most liquid among CHF money market rates.

For the SMB and HML, every July, we divide the companies along two axes (book-to-market ratio and market value measured at the end of June). More precisely, we split the firms into low, medium, and high book-to-market ratios at the 30th and 70th percentiles as well as small and big market values at the 50th percentile, as shown in Table C.1.

Table C.1: Fama–French Portfolios

		Market Value		
		Small	Big	
Book-to-Market	Low	Small-Low	Big-Low	30%
	Medium	Small-Medium	Big-Medium	40%
	High	Small-High	Big-High	30%
		50%	50%	

Notes: This table gives a schematic overview of how to build the six portfolios based on size and book-to-market equity ratio of firms from which we calculate the SMB and HML portfolios of the Fama-French three-factor model.

This yields six portfolios in which the companies stay for a year until the portfolios are rebuilt. Within each portfolio, we compute the equally- and value-weighted returns and compute the SMB and HML as follows:

$$SMB_{w,t} = \frac{1}{3}\left(r^{SL}_{w,t} + r^{SM}_{w,t} + r^{SH}_{w,t}\right) - \frac{1}{3}\left(r^{BL}_{w,t} + r^{BM}_{w,t} + r^{BH}_{w,t}\right) \tag{7}$$

$$HML_{w,t} = \frac{1}{2}\left(r^{SH}_{w,t} + r^{BH}_{w,t}\right) - \frac{1}{2}\left(r^{SL}_{w,t} + r^{BL}_{w,t}\right) \tag{8}$$

where $r^{p}_{w,t}$ represents the returns of portfolio p at the end of month t[11], in which the firms are either equally weighted or value weighted (w).

Descriptive statistics of the resulting Fama–French risk factors are reported in Table C.2, whereas the correlations between the factors are reported in Table C.3.

Table C.2 shows that the returns on the Fama–French risk factor-mimicking portfolios were, on average, positive in our sample period. In terms of absolute values, the minimum and maximum Rm-Rf values are similar but differ considerably for the SMB and HML. This observation seems to reflect the occurrence of several crisis periods in our sample, ranging from the euro area sovereign debt crisis and the coronavirus pandemic to the Russian invasion of Ukraine.

Table C.3 highlights that the SMB and HML are virtually uncorrelated with the market returns in our sample. As expected, the equally- and value-weighted counterparts of the SMB and HML are highly positively correlated (0.82 for the

[11] The same applies to daily versions of the SMB and HML.

Table C.2: Descriptive Statistics of the Fama-French Risk Factors (% per month)

	Rm-Rf	SMB (e.w.)	SMB (v.w.)	HML (e.w.)	HML (v.w.)
count	168	168	168	168	168
mean	0.70	-0.11	0.30	0.66	0.81
std	3.37	2.84	5.64	3.45	4.22
min	-8.43	-6.63	-6.27	-9.90	-6.40
P25	-1.14	-1.46	-1.86	-0.57	-0.93
P50	0.83	-0.32	-0.22	0.45	0.36
P75	2.97	0.65	1.51	1.54	1.80
max	8.49	20.79	54.79	36.26	46.08

Notes: This table provides descriptive statistics of the three Fama-French risk factors, i.e. the market excess return (Rm-Rf), the return difference between portfolios distinguishing between small and big firms (SMB) and the return difference between portfolios distinguishing between firms with high and low book-to-market equity ratios (HML). We compute versions of SMB and HML in which firm-level stock returns are either equal-weighted (e.w.) or weighted by their market value (v.w.). The table presents the mean excess return, its standard deviation, minimum, maximum and 25, 50 and 75% quantiles of the returns. The data frequency is monthly. The sample period spans July 2010 to June 2024.

SMB and 0.74 for the HML). The correlations between the different versions of the SMB and HML are on average positive, and the correlation coefficients range from 0.33 to 0.41. Judging by these correlations, we can expect that the three different risk factors capture different dimensions of systematic risk in the Swiss stock market.

Table C.3: Correlation between Fama-French Risk Factors

	Rm-Rf	SMB (e.w.)	SMB (v.w.)	HML (e.w.)	HML (v.w.)
Rm-Rf	1.00				
SMB (e.w.)	0.12	1.00			
SMB (v.w.)	0.11	0.82	1.00		
HML (e.w.)	-0.06	0.41	0.35	1.00	
HML (v.w.)	-0.01	0.37	0.33	0.74	1.00

Notes: This table provides pairwise correlation coefficients of the three Fama-French risk factors, i.e. the market excess return (Rm-Rf), the return difference between portfolios distinguishing between small and big firms (SMB) and the return difference between portfolios distinguishing between firms with high and low book-to-market equity ratios (HML). We compute versions of SMB and HML in which firm-level stock returns are either equal-weighted (e.w.) or weighted by their market value (v.w.). The data frequency is monthly. The sample period spans July 2010 to June 2024.

D Risk-adjusted BMG returns: three portfolios to form the simple spread BMG returns

This section provides a cross-check of whether the evidence of risk-adjusted returns on the BMG portfolio being essentially zero depends on the number of portfolios used to distinguish between brown and green firms. Therefore, we compute the simple spread BMG returns (equal-weighted or value-weighted) from allocating Swiss firms into three portfolios according to their CO_2 emissions (level or intensity), as in the main text. The BMG portfolio returns are then the difference between the third tercile (portfolio) and the first tercile (portfolio).

Table D.1 summarizes the estimates from regressing the BMG returns on a constant and the Fama–Franch risk factors. The qualitative results are similar to the baseline estimates provided in the main text. There is no evidence of a significant risk-adjusted return on the BMG portfolios. The return differences between brown and green portfolios can be explained by differences in the exposures to the HML factor.

Table D.1: Fama–French 3-Factor Model: Three Portfolios for BMG Simple Spread Returns

	Size-Adjusted Spread		V.W. Simple Spead		E.W. Simple Spead	
	(CO_2 Level)	(CO_2 Int.)	(CO_2 Level)	(CO_2 Int.)	(CO_2 Level)	(CO_2 Int.)
Intercept	-0.0029	-0.0007	-0.0027	0.0014	-0.0005	-0.0008
	(0.0019)	(0.0024)	(0.0025)	(0.0031)	(0.0020)	(0.0023)
Rm-Rf	0.0843	0.0953	0.0220	0.0301	0.0474	0.1140
	(0.0561)	(0.0718)	(0.0846)	(0.1001)	(0.0636)	(0.0730)
SMB (v.w.)	0.0583**	0.1610**	0.0660	0.2554		
	(0.0258)	(0.0643)	(0.0913)	(0.1646)		
HML (v.w.)	-0.1131***	-0.2345***	-0.1620**	-0.4007**		
	(0.0398)	(0.0781)	(0.0878)	(0.1871)		
SMB (e.w.)					-0.1184	-0.0131
					(0.0875)	(0.0841)
HML (e.w.)					-0.1119**	-0.1192*
					(0.0643)	(0.0674)
R^2	0.0572	0.1388	0.0503	0.1882	0.0586	0.0389
Adj. R^2	0.0399	0.1230	0.0329	0.1734	0.0414	0.0213
Observations	168	168	168	168	168	168

Notes: This table provides estimates from regressing each of the six variants of the carbon premium (BMG) in Swiss stock returns on the risk factors of the Fama-French three-factor model. The simple spread BMG returns are based on building three instead of five portfolios according to firms' CO_2 emissions (level or intensity). The factors are the market return (Rm-Rf), the return difference between portfolios of small and big firms (SMB) and the return difference between portfolios firms with high and low book-to-market equity ratios (HML). *, ** and *** denote statistical significance at the 10%, 5% and 1% level respectively. The data frequency is monthly. The sample period spans July 2010 to June 2024.

E Control variables for the panel regression

We use some of the variables listed in Appendix A to compute control variables for our panel regressions. These control variables are as follows:

- lagged (by one month) firm-level stock returns
- firm-level momentum returns (past returns from $t-12$ to $t-2$)
- exposure of firms' stock returns to oil returns computed from 60-month rolling window regressions. Oil returns computed with the data mentioned in Appendix A.
- exposure of firms' stock returns to gas returns computed from 60-month rolling window regressions. Gas returns computed with the data mentioned in Appendix A.
- exposure of firms' stock returns to commodity index returns from Bloomberg (SPGSCI:IND) computed from 60-month rolling window regressions
- size (log market capitalization)
- log book-to-market equity ratio
- growth in earnings per share (eps growth) from Worldscope (WC18198)
- growth in total assets (assets growth) from Worldscope (WC02999)
- log property plan and equipment (ppa) from Worldscope (WC02501)
- sales growth from Worldscope (WC01001)
- leverage: debt from Worldscope (WC03255) divided by total assets

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