Are Insurance Balance Sheets Carbon Neutral? Harnessing Asset Pricing for Climate-Change Policy

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Abstract

Due to its enormous size and capital base, the insurance industry should play a key role in countering climate change. To do so, the major capital flows associated with its investment and underwriting businesses must be redirected towards carbon-neutral activities. Since insurance companies can be viewed as large portfolios consisting of financial risks (asset side) and underwriting risks (liability side), we suggest an asset pricing approach to detect carbon-intensive positions on their balance sheets. The framework should be accompanied by two simple policy changes to reinforce its effectiveness.

Keywords: Climate Change, Sustainable Insurance, Carbon Emissions, Asset pricing
JEL classification: G12, G22, Q54, Q56

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1 Introduction

Climate change is one of the greatest challenges for humanity (King, 2004). According to recent estimates, the global average temperature has already risen by 1°C compared to preindustrial levels (see Hawkins et al., 2017). The dominant cause for this development are anthropogenic green house gas (GHG) emissions, which create temperature anomalies for many millenia (see Eby et al., 2009). Should the trend persist, earth will be faced with catastrophic and irreversible consequences such as ocean acidification, permafrost thawing, desertification, extreme weather, coastal flooding and the extinction of many species. Recent disasters such as hurricanes Harvey, Irma and Maria in 2017 could be harbingers of this development and, alarmingly, research consistently predicts more severe meteorological and hydrological events in the future (see Knutson et al., 2010). The impact of climate change on societies is expected to be devastating, ranging from famines and droughts to the uninhabitability of whole geographic regions.

On the positive side, serious efforts to stabilize carbon emissions are burgeoning. Since the ratification of the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, 24 conferences of the parties (COP) have been held. During the most recent summit of 2018 in Katowice, almost 200 nations agreed on binding rules for the implementation of the 2015 Paris Agreement (see UNFCCC Website). The major shift in energy generation and industrial practices associated with the long-term temperature goal of 2°C will require a significant redirection of global capital flows towards carbon-neutral infrastructure projects and technologies (see, e.g. Schmidt, 2014; World Economic Forum, 2013). Thus, the insurance industry as one of the largest contributors to the world's GDP bears a great responsibility. Recognizing their key role in countering climate change, many insurers have committed themselves to a comprehensive, enterprise-wide reaction. In a detailed survey of related engagements, Mills (2012) reports 1,148 initiatives from 378 institutions in 51 countries. Moreover, 2012 witnessed the introduction of the Principles for Sustainable Insurance (PSI), a voluntary framework supported by 65 entities (see UNEP, 2012).

While these are encouraging developments, the actual effectiveness of many of these activities remains unclear. In some cases, companies might merely pursue showcase projects such as investments in emission-reduction technologies or environmentally-focused funds on a smaller scale, simply because the mentioning of sustainable business practices resonates well with the public. For a real impact to materialize, however, insurance firms must consistently pursue green policies in their core investment and underwriting portfolios. The potential is enormous: estimates for the global insurance sector indicate around USD 25 trn in assets under management and almost USD 5 trn in nonlife premium volume (see Mills, 2012; Swiss Re, 2018b). A realloaction of just a fraction of these capital flows to low-carbon sectors of the economy could be a substantial catalyst for the achievement of climate goals. However, since existing frameworks are not binding and it is costly for stakeholders to scrutinize the industry, insurers might not be strongly incentivized to extend the green paradigm to their entire balance sheet. Apart from a recent article by Mielke (2018), the literature is astonishingly silent on this issue. We aim to take up the discussion by suggesting a novel policy framework, consisting of two main elements.

First, we develop a rapid test for carbon exposure in the investment portfolios of exchange-listed insurance companies based on asset pricing theory. More specifically, we enrich the 5-factor sector model of Ben Ammar et al. (2018) with an excess return series for traded GHG certificates. The latter must be purchased by "polluters" to cover their emissions in a given year, forcing them to internalize externalities associated with climate-wrecking activities. Through this new factor, we are able to capture long exposures to the CO_2 price hidden in insurance stock returns, thus unveiling the actual investment practices of the companies. This is important, since the actions of portfolio managers may deviate from their stated intentions, a phenomenon known as "style drift" in the fund industry (see Fung and Hsieh, 2002). We empirically implement our approach based on a rolling regression with a 48-month window on the stock return series of 35 European insurance companies from 2008 to 2018, and discuss the time-varying patterns in the carbon factor coefficients. In addition, we illustrate how the model can be extended to capture a broader range of sustainability criteria such as the exclusion of controversial weapons and nuclear energy as well as the adherence to occupational safety standards and human rights.

Second, we contemplate a number of complementary regulatory measures. An important question surrounds the institutionalization of the aforementioned carbon test and the consequences for firms, which exhibit a significant exposure to the CO_2 factor. In our view, the most natural way to address these issues is an extension of Solvency II. To begin with, insurers could be mandated to disclose the model's carbon coefficients and corresponding standard errors in both their annual report and their Solvency and Financial Condition Report (SFCR), allowing for a simple and low-cost evaluation of their climate neutrality by stakeholders and the general public. Being included in the SFCR, the respective information could then form the basis of an environmental, social, and governance (ESG) label for insurance companies. Such signals are already common in the investment fund industry (see, e.g., Ammann et al., 2018; Hartzmark and Sussman, 2019). As a further incentive for compliance, a markup (discount) in the capital charges for short (long) carbon exposures could be considered. This idea directly extends to the liability side of the balance sheet, which is not covered by our model. The reason is that technical reserves, even when valued in a market-consistent way, are not sensitive to changes in the price of CO_2. Hence, other measures are needed to discourage firms from insuring carbon-intensive facilities and infrastructures.

The remainder of this paper is structured as follows. In the next section, we briefly review the advent and dispersion of the sustainability paradigm in the insurance industry as well as the known effects of sustainability on asset prices. In the third section, we introduce the linear factor model that we want to harness for the detection of CO_2 positions in the investment portfolios of insurance companies. The fourth section contains an empirical analysis, demonstrating the capabilities of our rapid test for carbon exposure. In the penultimate section, we discuss important complementary policy changes. Finally, in the last section, we draw our conclusion.

2 Background and Motivation

2.1 Sustainability in Insurance

The global insurance industry is home to some of the world's largest institutional investors. With about USD 25 trn in assets under management, it commands more than 15 times the estimated annual gap (USD 1.6 trn) that needs to be closed by the private sector to achieve all 17 sustainable development goals (SDGs) by 2030 (see ECOSOC Chamber, 2018). Insurers and reinsurers differ from other asset managers such as mutual or hedge funds in that they pursue a liability-driven investment approach. This means that their portfolios are constructed in line with the predicted future insurance liabilities and leads to an overweighting of long-term investment-grade bonds. For the average asset portfolio of the U.S. insurance industry, e.g., Wong (2017) reports a 65 percent share of fixed-income securities compared to 12.5 percent stocks and only 4.2 percent cash and short-term investments. Given their long-term investment horizon as well as buy-and-hold strategy, insurers are well positioned to support the transition to the low-carbon economy by funding sustainable projects, particularly related to infrastructure. Due to its stable cash flows and long-term nature, the latter is a promising asset class that many insurers have begun to consider in the low-interest rate environment of the last decade (see, e.g. Karapiperis, 2017).

Despite its overwhelming potential to combat climate change, the global insurance industry has been adopting the sustainability paradigm at a modest speed. Merely 129 insurers worldwide undertook notable measures against global warming between 1995 and 2009, indicating that the majority remained on the sidelines (see Mills, 2012). In addition, it is unknown how many of those companies that do pursue green policies work with the most effective lever. More specifically, insurers may pursue a number of activities dealing with climate change and its consequences, such as science projects, loss prevention, technology investments and new product development, without consistently keeping their core investment and underwriting portfolios carbon neutral. Reported green investments comprise USD 23 bn in emission reduction technologies and USD 5 bn in environmentally focused funds (see Mills, 2012). A drop in the bucket compared to the industry's overall assets under management. Hence, for some insurers, green projects may be a fig leaf rather than a real effort to combat global warming.

The Principles for Sustainable Insurance (PSI), launched by the UNEP Finance Initiative in 2012, serve as an additional guidance for the insurance industry to address ESG risks and opportunities. Signatories of the PSI represent 25% of the worldwide premium volume. The four principles are i) integrating ESG issues in business decisions, ii) collaborating with clients and business partners to raise awareness and to develop solutions, iii) working with governments, regulators, and other stakeholders to promote action, and iv) disclosing the progress made with regard to the implementation of the principles. Unfortunately, the framework is non-binding and its implementation does not necessarily result in a reduction of carbon-intensive positions in the industry's investment or underwriting portfolios. In short, while the insurance sector would be capable of a substantial contribution to sustainable development, only a small proportion of its firms have voluntarily committed to explicit goals. For stakeholders, the cost involved in identifying truly sustainable insurers remains high.

From the shareholders' perspective, a vivid debate exists on the question whether sustainability and financial performance are a trade-off. There are theoretical arguments for both positive and negative relationships between sustainability and financial performance. Recent empirical studies support the former stance (see, e.g., Dorfleitner et al., 2018; Lins et al., 2017). Moreover, most evidence indicates that sustainability considerations in business activities do not result in a significantly reduced profitability, but mitigates risk. In particular, idiosyncratic risk and crash risk (a measure for tail risk) are lower for firms with a high level of ESG activities (see, e.g., Lee and Faff, 2009; Kim et al., 2014; Utz, 2018). In summary, integrating sustainability and climate change considerations into an insurance company's decision making does not require shareholders to determine priorities between different objectives. Yet, it enables executives to draw better informed decisions that lead to an economically sustainable insurance business.

2.2 Sustainability in Asset Pricing

The risk-return relationship is a long-studied topic in asset pricing with its modern origin being the capital asset pricing model (CAPM) (see Sharpe, 1964; Lintner, 1965; Mossin, 1966; Black et al., 1972). Over the last few decades, several multi-factor augmentations of the CAPM have been proposed (Fama and French, 1993; Carhart, 1997; Fama and French, 2015). Recently, Harvey et al. (2016) presented a list of more than 300 possible factors and Fama and French (2018) suggested a methodology on factor selection. The fundamental purpose of multi-factor models is to explain the return variation and risk premiums of assets. Applied to whole portfolios, their coefficients provide an indication of the constituent asset classes and investment styles (see Sharpe, 1992; Fung and Hsieh, 2002).

Extant research has revealed that the sustainability dimensions of a firm have a measurable impact on the performance of its stock and may thus be considered as an own risk factor. Khan et al. (2016) document that businesses yield significantly higher financial returns if they exhibit a good performance on material sustainability aspects. Similarly, Edmans (2011) finds significant positive abnormal returns for companies that treat their staff well and are listed among the best employers. Moreover, Hong and Kacperczyk (2009) provide evidence that norm-constrained institutions such as pension funds shy away from investing in companies with an exposure to controversial business activities. Therefore, their stocks offer higher expected returns.[1] Finally, the results of Bernardini et al. (2019) indicate significant alphas for portfolios of low-carbon stocks after the decarbonization process took off in 2012.

We presume it should also be possible to detect CO_2 exposures in portfolios by means of an adequately configured factor model. The economic mechanism underlying our reasoning looks as follows. Through their business model, polluters hold a short position in CO_2, i.e., they benefit (suffer) from falling (rising) carbon certificate prices through lower (higher) operating costs. Increases in the price of CO_2 therefore make carbon-intensive (green) investments less (more) attractive. Theoretically, this should apply to both equity investments as well as corporate bond investments. We capture the carbon price through actively traded GHG emission certificates. Those need to be acquired by polluters (e.g., coal-plant operators) to cover their CO_2 emissions, forcing them to internalize the associated externalities.[2] Intuitively, an insurer can be viewed as a combination of two portfolios, an investment and an underwriting portfolio. Therefore, carbon-intensive positions on the asset side of its balance sheet should leave traces in the returns of its own stock, which can be filtered out using a returns-based style analysis (see, e.g., Fung and Hsieh, 2002).

2.3 European Union Emission Trading Scheme

The prices for CO_2 that we use in this paper are from the European Union Emission Trading Scheme (EU ETS), the oldest and largest emission trading system worldwide. Its first phase was launched in January 2005 with the goal of achieving the climate targets established in the Kyoto Protocol, which contains explicit limits for the emission of climate-damaging gases, such as CO_2, per country. The EU ETS contributes to the reduction of such gases by turning the ability to emit them into a scarce resource. More specifically, it caps the emissions of entire economies at a specified level of tons of CO_2 in a certain period. The trading system focuses on carbon-intensive industries responsible for approximately 50% of the European CO_2 emissions. Those comprise, for instance, power generation, iron and steel, paper and cellulose, chemistry, and refineries. All registered facilities have to prove that they own enough allowances to cover their emissions at April 30 each year. In case of a shortfall, the operator of the facility has to pay 100 Euros per ton of extra emitted CO_2, and additionally has to deliver the missing number of emission allowances. The prosecution of such a misdemeanor is based on national legislation concretizing the respective EU directive (directive 2003/87/EC).

[1] Examples for such "sin stocks" are tobacco, alcohol and gaming enterprises.

[2] In 2005, the European Union Emission Trading System (EU ETS) was launched as the first GHG trading scheme in the world. Although the EU ETS was initially criticized for its large number of emission certificates, market fundamentals changed and prices increased notably in recent years.

To prevent a price shock in the first (test) period from 2005 to 2007, governments distributed the emission allowances[3] following a grandfathering mechanism. This means that a certain amount of CO_2 was allocated to each of the 11,000 facilities registered in the EU ETS based on their past emissions (including some reduction targets). If a facility was able to reduce its CO_2 emissions to a higher extent as expected, the operator was allowed to trade the free allowances. With the beginning of the third period (2013-2020), the distribution of emission allowances changed. Henceforth the EU only distributed about 60% of the certificates, whereas the additional 40% could be purchased by polluting firms. Coal power stations are an exception, since they have to purchase all necessary emission allowances through the trading system at market prices.[4] During this third period, prices for emission allowances have substantially increased from 6.50 Euro in January 2013 to 25 Euro in June 2019. The current price translates into a CO_2-induced cost-pressure for the operator of an average coal plant of about 10% of the market price per kilowatt hour (kwh) of produced electricity and is thus significant.[5]

3 Model Framework

To isolate the impact of CO_2-price exposure and avoid omitted variable bias, our model needs to control for key factors that are known to explain the return time series of insurance stocks. We therefore adopt the insurance-specific five-factor asset pricing model (INS5) of Ben Ammar et al. (2018) and extend it with our carbon factor (CO2):

$$\begin{aligned} R^e_{i,t} &= \alpha_i + \beta_{i,\text{MKT}}\text{MKT}_t + \beta_{i,\text{HMLINS}}\text{HMLINS}_t + \beta_{i,\text{PRETINS}}\text{PRETINS}_t \\ &+ \beta_{i,\text{ROEINS}}\text{ROEINS}_t + \beta_{i,\text{SPREADINS}}\text{SPREADINS}_t + \beta_{i,\text{CO2}}\text{CO2}_t + \epsilon_{i,t}, \end{aligned} \tag{1}$$

where $R^e_{i,t}$ denotes the excess return of stock i in time period t, α_i is the intercept for stock i, $\beta_{i,F}$ represents the loading on factor F and $\epsilon_{i,t}$ is the idiosyncratic error term. The original INS5 model comprises the following factors: the market index (MKT), a zero-investment portfolio sorted by the book-to-market (b/m) ratio of insurance stocks (HMLINS), a zero-investment portfolio sorted by prior month return of insurance stocks (PRETINS), a zero-investment portfolio sorted by the return on equity (ROE) of insurance stocks (ROEINS), and the return difference between insurance stocks and the entire market (SPREADINS).[6] We add the carbon factor to capture GHG exposures on the asset side of the insurers' balance sheets. Positive β_{CO2} (carbon betas) indicate net long positions in green assets, since the portfolio value increases when GHG emission certificates become more expensive. Conversely, negative

[3] One CO_2 emission certificate permits the owner to emit one ton of CO_2 or other gases that damage the climate in the same intensity.

[4] Exceptions existed for coal plants in Eastern-European countries.

[5] An average brown coal power station is able to produce one kwh of electricity at the emission of 1.1 kilogram CO_2. The current market price for one kwh on the German electricity market is approximately 0.30 Euro and the cost for the emission allowances per kwh is approximately 0.03 Euro.

[6] We construct HMLINS, ROEINS, and PRETINS slightly differently than Ben Ammar et al. (2018), since the latter developed their model for U.S. property-liability insurers, whereas we work with European data. More specifically, we sort the sample insurance stocks by the respective characteristics (previous-year b/m ratio, previous-year ROE, previous-month return) and form equally-weighted tercile portfolios. The risk factors are then derived by subtracting the last tercile (lowest value) from the first tercile (highest value) portfolio.

coefficients point towards polluters, whose profitability is negatively affected by rising CO_2 prices.[7] All factors are measured in excess returns.

In a second analysis, we further extend the INS5 model with a broad sustainability factor (FNGO):

$$\begin{aligned} R^e_{i,t} &= \alpha_i + \beta_{i,\text{MKT}}\text{MKT}_t + \beta_{i,\text{HMLINS}}\text{HMLINS}_t + \beta_{i,\text{PRETINS}}\text{PRETINS}_t + \beta_{i,\text{ROEINS}}\text{ROEINS}_t \\ &+ \beta_{i,\text{SPREADINS}}\text{SPREADINS}_t + \beta_{i,\text{CO2}}\text{CO2}_t + \beta_{i,\text{FNGO}}\text{FNGO}_t + \epsilon_{i,t}. \end{aligned} \tag{2}$$

To construct FNGO, we first form a factor FNG, which reflects the excess returns of an equally-weighted portfolio of 88 mutual funds with FNG label. The abbreviation FNG stands for "Forum Nachhaltige Geldanlagen" (see FNG website), an initiative that awards its sustainability label to fund managers in German-speaking Europe, given that they satisfy a transparent set of minimum criteria such as the exclusion of weapons manufacturers and coal-plant operators. It signals investors that the funds consistently pursue a rigorous sustainability strategy in line with internal standards. Since the excess return series of FNG is influenced by general stock market movements and likely includes a high concentration of green businesses, we orthogonalize on MKT and CO2 through the following regression:

$$\text{FNG}_t = \gamma + \delta_{\text{MKT}}\text{MKT}_t + \delta_{\text{CO2}}\text{CO2}_t + u_t. \tag{3}$$

FNGO is obtained by adding γ and u_t. In other words, we strip FNG of the variance that is explained by the market and the carbon factor, thereby exclusively leaving those parts that are neither attributable to general stock market nor carbon allowance volatility. Thus, FNGO allows us to separately detect exposures to further sustainability dimensions. Equations (1) to (3) are estimated by means of OLS and Newey-West HAC standards errors with lags of four.

4 Empirical Analysis

4.1 Data and Descriptive Statistics

Our sample consists of 35 European insurance companies included in the STOXX Europe 600 Insurance index as of Februray 2019. For each company, we collect monthly returns as well as year-end b/m ratios and ROEs spanning the period from December 2007 to January 2019 from Datastream. Furthermore, we proxy the risk-free interest rate between January 2008 and December 2018 through the one-month Euribor (Euro Interbank Offered Rate). The latter is obtained from Bloomberg together with returns of the STOXX All Europe Total Market index, which we use as the market factor MKT. To construct HMLINS, PRETINS and ROEINS, we sort the 35 insurance stocks according to their b/m ratios (annual basis), prior month returns (monthly basis) as well as ROEs (annual basis), and group them into terciles for each month. The return time series of the zero-investment portfolios that constitute the factors are obtained by subtracting the equally-weighted excess returns of the lowest from those of the highest tercile

[7] To validate this effect, we collected monthly stock return data over the period of January 2017 to December 2018 from two types of companies based in Europe: (i) "green" business models (e.g. from the renewable energy sector) and (ii) carbon-intensive business models (e.g. from the fossil fuel industry). Subsequently, we regressed the excess return time series of each company on the European five-factor asset pricing model of Fama and French (2015) plus the CO_2 factor. The excess return series for the five European Fama-French factors were obtained from Ken French's library. In line with those factors, the excess returns of the European stocks and the CO_2 factor were converted to USD. We found the average β_{CO2} of "green" companies (0.16) to be higher than the average β_{CO2} of carbon-intensive companies (-0.11), on a statistically significant level ($p = 0.010$). The respective results are available from the authors upon request.

portfolio. Finally, we construct SPREADINS by subtracting MKT from the monthly excess returns of the STOXX Europe 600 Insurance index. All price and accounting data is denominated in Euro.

Carbon prices are measured through the European Climate Exchange EU Allowances (EUA ECX) futures continuous contract. For a gapless time series, we merge data of investing.com and quandl.com and calculate the associated excess returns for CO2. Finally, we end up with a return series for carbon prices from April 2008 to December 2018. In addition, we consult the FNG website for the list of funds that have received the FNG label starting in the year 2016. We collect the monthly returns of those funds for the period January 2016 to January 2019 from Datastream, form an equally-weighted portfolio and subtract the risk-free rate series to obtain the excess returns for FNG. Those are then orthogonalized on MKT and CO2 as described in the previous section, leaving us with FNGO. Table 1 presents descriptive statistics for the factors.

Table 1 Descriptive statistics

	Mean	Volatility	Median	Min.	Max.	Skewness	Kurtosis	Obs.
MKT	−0.379	4.930	0.136	−24.996	9.840	−1.379	4.308	129
HMLINS	0.210	1.319	0.247	−3.415	6.211	0.705	3.203	129
PRETINS	−0.104	1.732	−0.266	−9.998	6.904	−0.272	10.238	129
ROEINS	0.257	1.891	0.172	−8.782	9.559	0.174	9.068	129
SPREADINS	0.196	3.473	0.746	−11.044	12.968	−0.228	1.495	129
CO2	0.847	16.552	1.690	−50.796	57.052	0.044	1.184	129
FNGO	0.080	0.509	0.063	−1.601	1.015	−0.702	1.547	36

The table presents the mean, volatility, median, minimum, maximum, skewness, kurtosis, and number of observations for the monthly excess return series of each factor. The data for MKT, HMLINS, PRETINS, ROEINS, SPREADINS and CO2 covers the time period from April 2008 to December 2018. The FNGO series is available from January 2016 to December 2018.

The MKT series exhibits a negative mean of −0.379% (−4.54% p.a.), because the sample includes a number of extreme observations from the global financial crisis in 2008. HMLINS and ROEINS show positive means of 0.210% (2.55% p.a.) and 0.257% (3.084% p.a.), respectively. In contrast, the average excess return of PRETINS is −0.104% (−1.248% p.a.). These figures are consistent with those of Ben Ammar et al. (2018) for the INS5 factors in the U.S. stock market. The mean of 0.196% (2.352% p.a.) for SPREADINS indicates a positive historical return spread of the European insurance sector over the main market. Turning to our carbon and sustainability factors CO2 and FNGO, we find average excess returns of 0.847% (10.164% p.a.) and 0.080% (0.960% p.a.), respectively. The former mirrors the substantial increase in the price of GHG certificates during the past decade, putting pressure on polluter business models. The relatively low mean of FNGO, in contrast, suggests that adherence to other sustainability dimensions has not been associated with high excess returns in the European market.

4.2 A Rapid Test of Carbon Exposure

Below we discuss our main empirical analysis. For all 35 insurance[8] stock return time series in our sample, we run a rolling regression with 48-month window, repeatedly estimating Model (1) over the period from April 2008 to December 2018. This results in a sequence of carbon betas for each insurer, reflecting the time-varying CO_2-price exposure of its investment portfolio. We exclude three insurers with short time series, leaving us with a remaining sample of 32 firms that exhibit regression results for at least 50

[8]For anomymization, the names of insurers have been redacted. The anecdotal evidence mentioned in Section 4.2 and Section 4.3 can be found in Allianz (2018), Generali (2018), Aviva (2018), Buthelezi (2019), Storebrand (2018), Swiss Re (2018a), Munich Re Website, and Reuters.

subsequent estimation windows. The entire analysis relies on publicly available excess return data for the insurance companies and the risk factors, but does not require any labor-intensive manual analysis of annual reports or investor relations releases. Hence, it is a "rapid test" of carbon exposure in the asset allocations of insurers. The corresponding results are depicted in Figure 1.

The majority of insurers in our sample show a more or less pronounced increase in the carbon beta in 2018. This consistently mirrors the many recent declarations of well-known industry constituents to explicitly pursue decarbonization strategies. For example, in 2018, *Insurer 20* (*Insurer 14*) announced cease of investment in companies with more than 30% (25%) of their revenues from coal mining or coal-based energy production. Any such remaining assets were meant to be sold by the end of the year. Similarly, following their adoption of ESG benchmarks in 2017, *Insurer 33* reported in June 2018 that it applied the corresponding criteria to close to 100% of its asset portfolio. The most striking effect, however, is associated with the climate-change strategy of *Insurer 6*, developed in the firm's Responsible Investment Guideline in 2015. Significantly positive carbon betas for 2018 indicate that this insurance group did not only withdraw from carbon-intensive assets, but it seems to have reallocated a nonnegligible quantity of the respective funds to green investments. Together with *Insurer 26*, *Insurer 6* is the only European insurance company for which we document such results. Another special case is *Insurer 4*, which, as a real pioneer, adopted an explicit climate change strategy as early as 2012. According to our estimates, it has indeed been running a CO_2-neutral investment portfolio since.

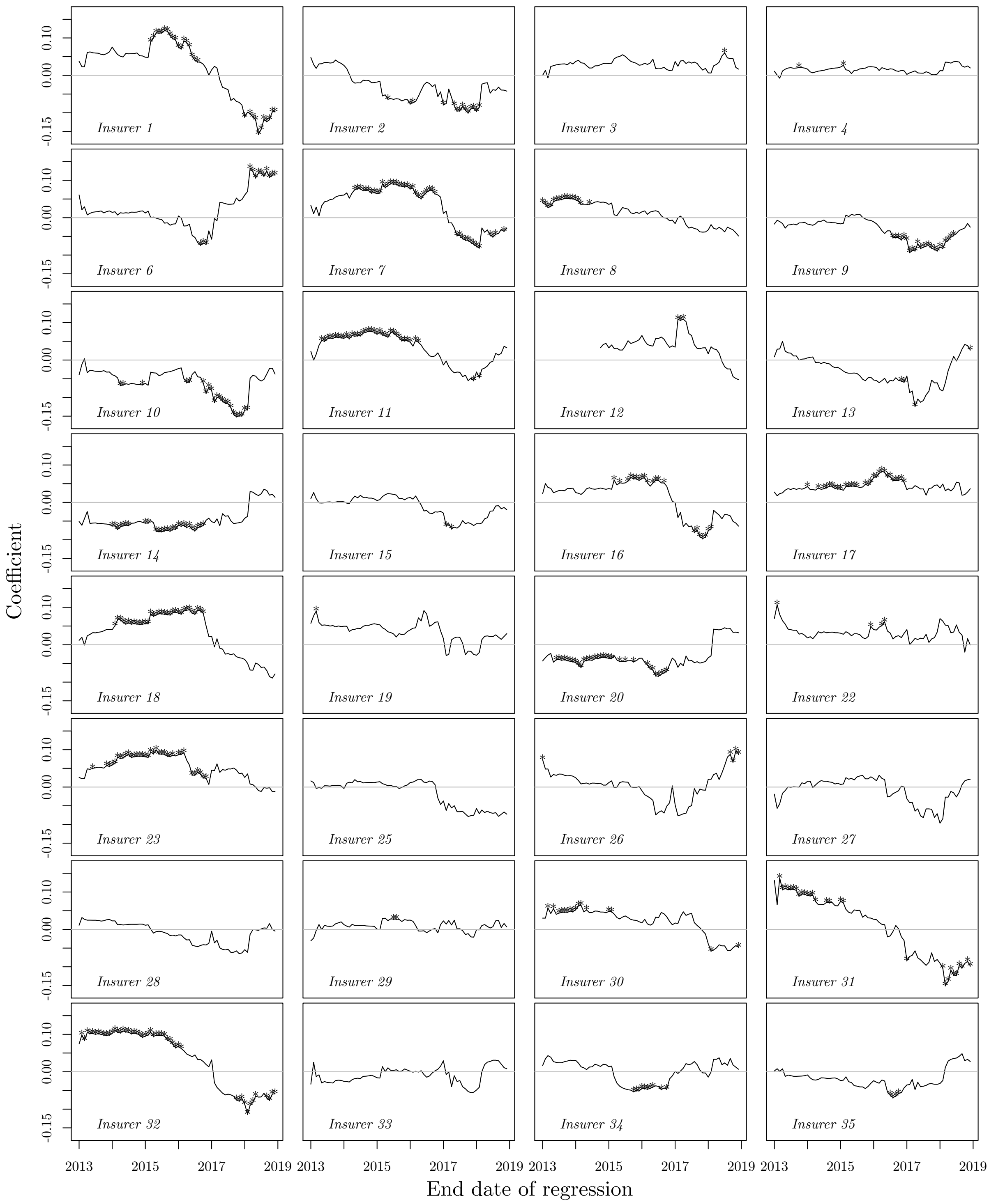
Against the general societal trend towards sustainability, a number of insurers still exhibited significantly negative carbon betas at the end of 2018. In this group are firms such as *Insurer 1*, *Insurer 7*, *Insurer 30*, *Insurer 31* and *Insurer 32*.[9] Consider *Insurer 7*, e.g., which declared itself the first carbon-neutral international insurer in 2006 and contributed over GBP 500 mn of investments to wind, solar, biomass and other renewable energy projects. Despite the low CO_2 emissions profile of the insurer itself, large parts of its investment portfolio seem to be allocated to polluting assets. These results document the importance of a look-through approach and the superiority of our rapid test based on a return-based style analysis over a manual screening of financial statements. The fact that we pick up a carbon exposure in these insurers' investment portfolios indicates a discrepancy between their affirmations and actual behavior.

4.3 Detecting Further Sustainability Dimensions

Since the 17 Sustainable Development Goals comprise social and governance topic besides environmental ones, we continue our analysis with the estimation of Model (2) for each of the 35 European insurance companies. A time series of returns that represents possible anomalies stemming from such non-financial aspects could be derived from the returns of funds being awarded with the FNG sustainability fund label. Those funds are free of assets with an exposure to business activities incompatible to the ten norms of the UN Global Compact. Moreover, the firms do not operate in the anti-human weapon sector, have low or no exposure to burning coal, low or no exposure to running and supporting nuclear energy generation and low or no exposure to oil sand quarries. To avoid multi-collinearity issues among MKT, CO2 and the sustainability factor, we apply the orthogonalization explained in Section 3. Since FNG launched its fund label in 2016, the returns of the FNGO factor are available for a three years period ranging from 2016 to 2018.

[9]The carbon beta of *Insurer 18* displays a similar evolution over time but ends up insignificant in 2018.

Figure 1 Individual insurer's CO2 coefficient as a function of time.



This figure displays the CO2 coefficient of each insurer as a function of time. The coefficients are estimated in Model (1) for each insurer separately. We apply a 48-month rolling window to estimate the coefficients of the regression model. The first set of 48 monthly return observations ends in January 2013, the last set of 48 observations ends in December 2018. Standard errors are based on the Newey-West HAC covariance matrix with lags of four. Coefficients with a significance level of 0.1 or below are marked by "*". We exclude insurers with shorter times series than 50 rolling windows (*Insurer 5*, *Insurer 21* and *Insurer 24*) from this analysis.

Table 2 Regression analysis.

Company name	Intercept	MKT	HMLINS	PRETINS	ROEINS	SPREADINS	CO2	FNGO
Insurer 1	1.443**	0.501**	−3.785***	1.094	−1.466	0.747***	−0.079**	1.373
	(0.026)	(0.028)	(0.002)	(0.186)	(0.200)	(0.000)	(0.011)	(0.166)
Insurer 2	−0.283	1.246***	3.296**	−0.135	−0.866	0.995***	−0.049	−1.527
	(0.776)	(0.000)	(0.025)	(0.902)	(0.512)	(0.003)	(0.521)	(0.381)
Insurer 3	−0.153	0.949***	0.890	−0.994	0.682	0.912***	0.015	−0.759
	(0.708)	(0.000)	(0.294)	(0.235)	(0.508)	(0.000)	(0.623)	(0.428)
Insurer 4	−0.075	1.246***	2.343***	0.924	0.762	0.761***	0.013	1.031*
	(0.866)	(0.000)	(0.006)	(0.160)	(0.125)	(0.000)	(0.723)	(0.070)
Insurer 5	1.307***	0.928***	4.046***	0.439	0.959***	0.125	−0.015	1.688***
	(0.001)	(0.000)	(0.000)	(0.245)	(0.001)	(0.185)	(0.492)	(0.000)
Insurer 6	−0.610	1.559***	1.492*	0.530	1.598*	1.040***	0.081**	−2.559**
	(0.205)	(0.000)	(0.056)	(0.457)	(0.073)	(0.000)	(0.020)	(0.050)
Insurer 7	−1.038*	1.119***	−0.120	−2.151***	−0.402	0.656***	−0.012	−1.511**
	(0.090)	(0.000)	(0.891)	(0.001)	(0.587)	(0.000)	(0.586)	(0.028)
Insurer 8	−1.032**	1.566***	4.100***	−0.159	1.988**	1.166***	−0.063	0.538
	(0.022)	(0.000)	(0.000)	(0.802)	(0.016)	(0.000)	(0.123)	(0.391)
Insurer 9	−0.074	1.058***	2.011***	0.868*	0.853	0.176	−0.027	1.470*
	(0.847)	(0.000)	(0.008)	(0.071)	(0.179)	(0.306)	(0.294)	(0.095)
Insurer 10	0.977	0.679**	−3.796**	−1.770**	−1.209	0.470	−0.005	2.140*
	(0.228)	(0.020)	(0.017)	(0.023)	(0.413)	(0.101)	(0.942)	(0.072)
Insurer 11	1.072**	1.096***	2.261**	1.958*	−0.443	0.080	−0.002	0.778
	(0.032)	(0.000)	(0.031)	(0.055)	(0.550)	(0.780)	(0.958)	(0.438)
Insurer 12	−0.425	0.984***	−0.934	1.071	−0.245	0.409	−0.018	−2.979**
	(0.489)	(0.000)	(0.472)	(0.324)	(0.830)	(0.237)	(0.667)	(0.047)
Insurer 13	−0.166	0.054	−0.781	0.851	0.506	−0.087	0.076***	1.643**
	(0.720)	(0.786)	(0.236)	(0.264)	(0.594)	(0.479)	(0.005)	(0.045)
Insurer 14	0.094	0.509**	0.744	1.132*	−0.401	0.557***	0.061**	2.561***
	(0.808)	(0.029)	(0.293)	(0.058)	(0.567)	(0.000)	(0.013)	(0.000)
Insurer 15	0.197	0.186	0.256	−0.357	−0.579	0.070	0.012	0.609
	(0.635)	(0.394)	(0.710)	(0.421)	(0.380)	(0.702)	(0.560)	(0.331)
Insurer 16	1.400**	0.756***	−2.981***	0.105	−0.482	0.493***	−0.019	1.672
	(0.012)	(0.003)	(0.009)	(0.873)	(0.651)	(0.006)	(0.717)	(0.102)
Insurer 17	2.419*	0.789**	−2.737	−0.286	−1.312	0.738**	0.012	−1.285
	(0.085)	(0.032)	(0.147)	(0.781)	(0.533)	(0.018)	(0.844)	(0.397)
Insurer 18	0.134	1.541***	−1.594*	−1.555*	−0.119	1.039***	−0.079	−3.156**
	(0.876)	(0.000)	(0.072)	(0.087)	(0.904)	(0.006)	(0.302)	(0.046)
Insurer 19	0.174	0.981***	1.337	0.417	−1.364	0.725**	0.015	1.054
	(0.792)	(0.000)	(0.395)	(0.667)	(0.287)	(0.033)	(0.801)	(0.333)
Insurer 20	0.141	0.645***	0.328	1.137	−0.304	0.409	0.059	0.075
	(0.730)	(0.003)	(0.787)	(0.300)	(0.677)	(0.116)	(0.207)	(0.940)
Insurer 21	0.228	1.047***	1.846	−0.689	0.543	0.951***	0.013	−1.306
	(0.705)	(0.000)	(0.121)	(0.369)	(0.530)	(0.000)	(0.696)	(0.321)
Insurer 22	0.443	0.552**	−1.455	2.104*	−3.217***	−0.108	0.047	3.653***
	(0.525)	(0.015)	(0.464)	(0.066)	(0.000)	(0.665)	(0.161)	(0.005)
Insurer 23	−0.855	0.786***	−0.456	−1.781**	−0.025	0.360*	−0.001	−0.320
	(0.138)	(0.000)	(0.645)	(0.013)	(0.977)	(0.057)	(0.970)	(0.752)
Insurer 24	0.167	0.644**	−1.255	0.865	−2.370**	0.468**	0.148***	−1.227
	(0.785)	(0.019)	(0.110)	(0.472)	(0.041)	(0.013)	(0.000)	(0.275)
Insurer 25	−0.236	1.741***	−0.042	−0.481	0.412	0.755*	−0.087	−0.053
	(0.785)	(0.000)	(0.974)	(0.592)	(0.684)	(0.068)	(0.396)	(0.971)
Insurer 26	0.317	1.048**	3.032***	3.059**	3.160**	0.299	0.030	1.624
	(0.731)	(0.019)	(0.005)	(0.015)	(0.011)	(0.390)	(0.477)	(0.202)
Insurer 27	0.605	0.634***	−2.386**	1.057*	−2.398***	0.087	0.034	1.071
	(0.369)	(0.000)	(0.010)	(0.090)	(0.002)	(0.706)	(0.124)	(0.108)
Insurer 28	−0.531	0.666***	0.520	−0.095	0.884	0.596***	0.017	0.462
	(0.178)	(0.000)	(0.524)	(0.874)	(0.133)	(0.000)	(0.480)	(0.343)
Insurer 29	0.359	0.710**	1.269	0.472	−0.319	0.516**	0.031	0.957
	(0.708)	(0.011)	(0.250)	(0.601)	(0.790)	(0.041)	(0.481)	(0.380)
Insurer 30	−0.329	1.432***	−1.602*	−1.744**	0.536	0.816***	−0.025	1.019
	(0.389)	(0.000)	(0.059)	(0.039)	(0.494)	(0.000)	(0.339)	(0.189)
Insurer 31	1.117	0.968***	5.376***	−0.159	1.885	0.503	−0.089*	3.231**
	(0.161)	(0.002)	(0.001)	(0.913)	(0.218)	(0.161)	(0.079)	(0.024)
Insurer 32	0.966*	0.686***	1.435*	−0.930	1.418**	0.505**	−0.041	−0.174
	(0.079)	(0.001)	(0.078)	(0.176)	(0.025)	(0.035)	(0.151)	(0.851)
Insurer 33	−0.080	0.187	−0.467	1.571**	−0.583	0.581***	0.070***	0.355
	(0.862)	(0.276)	(0.576)	(0.015)	(0.342)	(0.003)	(0.006)	(0.616)
Insurer 34	0.631	0.481**	−0.331	0.413	0.623	0.143	0.035	0.215
	(0.166)	(0.017)	(0.631)	(0.577)	(0.283)	(0.425)	(0.357)	(0.789)
Insurer 35	0.144	0.645**	0.680	0.016	0.200	0.142	0.046	1.040
	(0.874)	(0.037)	(0.508)	(0.979)	(0.799)	(0.535)	(0.250)	(0.439)

This table reports upon the results of the time series regressions for Model (2) for each of the 35 European insurance companies. Each regression contains monthly observations from January 2016 to December 2018. The row names denote the respective insurance company. Each column contains the estimates of the coefficients labelled in the column heading, i.e., the first column ("Intercept") shows the abnormal return of each insurance company, the second column shows the market beta ("MKT") and the remaining columns show the coefficients of the additional risk factors. We also report Newey-West adjusted p-value in parentheses below each coefficient. The significance level of 0.1, 0.05 and 0.01 is denoted by *, ** and ***, respectively.

Table 2 includes the results of this analysis, which we applied for each individual insurance company separately. The carbon beta of each firm in Table 2 is generally consistent with the estimate of the carbon beta for the latest period in our rolling window approach displayed in Figure 1. This is an indication for the robustness of our results since the modification in the length of the time series and the integration of an additional sustainability factor does not substantially change the results of Model 1. *Insurer 1* and *Insurer 31* are examples for significantly negative carbon betas in both model, *Insurer 6* and *Insurer 13* for positive carbon beta.

For several companies only one of the two factors (CO2, FNGO) is significant. Moreover, we observe cases, in which the carbon betas and sustainability coefficients exhibit opposite signs. This indicates that examining the carbon factor is not sufficient for a comprehensive analysis of the extent to which insurance companies align their investment portfolios with ESG criteria beyond the carbon intensity. The inclusion of FNGO provides more insights on how a company rooted the broader sustainability paradigm in its asset allocation. FNGO is one channel to classifying firms as being (un)sustainable on a broader scope. *Insurer 22*, e.g., shows little green exposure, yet is identified to have a significantly positive loading on the FNGO factor. This can be explained by investments that focus on other sustainability dimensions than carbon intensity. In November 2018, *Insurer 22* launched South Africa's first ESG index unit trust funds that "exclude alcohol, gambling, tobacco, nuclear power and weapons".

Other insurers such as *Insurer 5*, *Insurer 7* and *Insurer 18* turn out to have significantly negative loadings on the FNGO factor, indicating a noncompliance with sustainability aspects. Some insurance firms are compliant with either the carbon or the FNGO factor. E.g., as already mentioned, *Insurer 6* is one of the pioneers in focusing on green assets, indicated by a significantly positive carbon beta. However, it shows a negative exposure towards the FNGO factor. The pattern for *Insurer 31* is inverse. In accordance with its Sustainability Investment Policy, *Insurer 31* commits itself to ethical investment excluding companies that are heavily engaged in business ranging from tobacco to gambling. Furthermore, *Insurer 31* admits that it is holding carbon-associated funds and subtly insinuates that for some of those funds, the carbon footprint might be high from time to time. Instead of divesting, the insurer promises to "engage with and encourage" those investees "to improve to reduce their carbon footprint." Hence, *Insurer 31*'s FNGO-compliance ($\beta_{\text{FNGO}} > 0$) and high exposure to carbon prices ($\beta_{\text{CO2}} < 0$) is consistent with the results of our rapid test.

5 Complementary Policy Changes

5.1 Disclosure Requirements and ESG Label

To reinforce its effectiveness, the rapid test for carbon exposure presented above needs to be embedded in a policy framework. According to Mills (2012), "insurance regulators and investors are seeking climate-risk disclosure, compelling insurers to formally consider climate change in operational, business, and investment practices [...]." In line with this view, we advocate mandatory disclosure requirements. Two obvious conduits are the annual report as well as the SFCR governed by pillar 3 of Solvency II, which insurers must regularly publish according to strict guidelines (see EIOPA, 2015). Either one could be extended by carbon betas, their standard errors, and an interpretation of the results, including their historical evolution. Complementary lists of carbon-intensive and green assets could be provided in an online-appendix. In contrast to lengthy verbal explanations, this would offer stakeholders and regulators a quantified, reliable and easily verifiable assessment of the degree to which insurers' investment portfolios are climate compliant. The idea is naturally extendable to the broader set of sustainability dimensions, which can be tested with our FNGO-model. Recent advances of the European regulator EIOPA indicate that such a solution has the potential to find majorities among policymakers (see EIOPA, 2018; **?**). Even without a regulatory obligation, signatories of the PSI initiative discussed in the second section should be pursuing such a heightened degree of transparency themselves.

Another consideration is the introduction of an ESG label for insurers to further increase transparency regarding climate risks. In the mutual fund space, such signals are already common (see Hartzmark and Sussman, 2019). An example is the FNG label that we employed to construct our sustainability factor in the previous section. Clearly, insurers cannot simply be deemed low-carbon based on an assessment of their own emissions. Instead, as outlined in previous sections of this paper, the most important climate-levers are their investment and underwriting activities. Hence a look-through approach is key, taking into account the CO_2 exposures in the companies' core portfolios. Based on the output of our carbon-exposure test for the asset side, an efficient climate label could be designed with three different ranks or badges: polluting (significantly negative carbon betas), climate-neutral (insignificant carbon betas) and green investment portfolios (significantly positive carbon betas). Naturally, the same idea would work for a full sustainability label, using our FNGO-extended factor model. An ESG label established on the quantitative basis of our asset pricing approach should be a strong signal, allowing stakeholders to reliably identify climate-friendly and sustainable insurers. Interestingly, first industry pioneers are arguing that a common classification system for sustainable insurers is needed and policymakers should consider the inclusion of ESG-criteria in regulatory frameworks (see Sheehan, 2019)

5.2 Capital Charges

While the disclosure requirements for climate risks in their balance sheets can generally lessen the attractiveness of carbon-intensive investments for insurance companies, a current study by Mielke (2018) showed that, on their own, they have only moderate potential to bias insurers' investment decisions towards green assets. An adjustment of the Solvency II capital charges, in contrast, is considered to be more promising. Instead of performing a costly and intricate analysis of the carbon-intensity of each individual position in an insurer's investment portfolio, however, we suggest to consider a modification of the overall Solvency Capital Requirement (SCR) on the company level. More specifically, given our carbon-exposure test for listed insurance companies, it would be straightforward to introduce a regulatory capital discount for green (positive carbon betas) and a markup for polluting investment portfolios (negative carbon betas). Inspiration can be drawn from the EU's Capital Markets Union Initiative, under which high quality infrastructure assets obtain favorable Solvency II capital treatment. Braun et al. (2017) have shown that the capital charges can have a major influence on the asset allocation of insurance companies. Hence, the inclusion of climate or even ESG considerations in the first pillar of Solvency II should be a strong lever for the redirection of the investment flows in the European insurance sector. Clearly, this would constitute a quite far-reaching extension of the main objective of Solvency II, i.e., the protection of the policyholders. Whether the protection of the climate should be added as an additional goal must be determined through an intensive political discussion among the EU member states. One consequence that needs to be taken into account is the likely rise in premiums for customers of insurers with negative carbon betas due to their increased capital requirements. While this appears to be an undesired effect at first glance, the associated declines in demand experienced by carbon-intensive insurers could even further accelerate the industry's transition to carbon neutrality.

6 Conclusion

Owing to its enormous size and capital base, the insurance industry should occupy a key role in the achievement of UNFCCC climate goals. If only a fraction of the sector's USD 25 trn in investments worldwide could be directed away from carbon-intensive assets, this would constitute a substantial contribution to the efforts against global warming. It is doubtful, however, whether voluntary initiatives will be enough to genuinely implant the sustainability paradigm into the industry DNA.

Since insurance companies can be viewed as large portfolios consisting of financial risks (asset side) and underwriting risks (liability side), we suggest an asset pricing approach to detect carbon-intensive positions on their balance sheets. Our model extends the insurance-specific five-factor framework of Ben Ammar et al. (2018) by the excess returns on GHG allowances. Owing to the long (short) position in the price of CO_2 implied by their business fundamentals, green (polluter) firms can be expected to exhibit a positive (negative) carbon factor beta. As these effects feed through to the portfolio level, they should be measurable in the excess return time series of the insurers' stocks. We empirically implement the model based on rolling regressions and illustrate the evolution of the carbon footprint of 35 European insurance companies over the last years. In addition, we test a further specification, including the carbon factor and a proxy for a broad range of other sustainability dimensions. Finally, we discuss two straightforward policies measures that could be pursued to reinforce the effectiveness of the CO_2 test. On the one hand, regulators and investors should aim for a new set of disclosure requirements based on the carbon betas, compelling insurers to factor the climate perspective into their investment decisions. Those could be complemented by a new ESG label, either for green or even for fully sustainable insurers. On the other hand, we enrich the debate by a potential modification of the Solvency II capital requirements, based on our carbon betas.

Further analyses are required to tackle the limitations of our work. First, while the suspected link between the carbon price and stock returns is plausible, more research is needed regarding the relationship to bond returns. The question is to which extent our model picks up nongreen fixed income positions in investment portfolios. This is a key issue, since the asset allocation of insurance companies comprises around 60% to 70% of government and corporate debt. Second, one should not forget the liability side of the balance sheet. The market value of insurance contracts only reacts to shifts in risk fundamentals, but not to changes in the price of CO_2. Thus, our model cannot detect GHG exposures in the insurers' underwriting business. This may result in a situation in which firms appear to be climate compliant, because they run a low-carbon asset portfolio, while still writing coverage for coal plants. Yet, the introduction of an ESG label for insurance companies only makes sense, if it also covers their liability side. Although there are no straightforward solutions to these issues, considering the high stakes associated with climate change, their further consideration is well worth the effort.

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