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Awareness of climate risks and opportunities: empirical evidence on determinants and value from the U.S. and European insurance industry

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Abstract

In this paper, we study the awareness of European and U.S. insurance companies of climate-related risks and opportunities using a respective indicator from the Refinitiv Eikon database that uses reporting data. Based on this, we examine the determinants and value of the awareness of business risks and opportunities resulting from climate change, which, to the best of our knowledge, has not been done so far, despite its increasing and specific relevance for the insurance industry. We use a logistic regression analysis as well as a linear fixed effects model for a 10-year period from 2009 to 2018. Our results show that larger European insurers are significantly more likely to exhibit such awareness. When controlling for subsectors, property & casualty insurers tend to be aware of the risks and opportunities resulting from climate change. Moreover, when using the linear fixed effects model, we find a statistically significant positive value effect on Tobin's Q.

Keywords Climate change · Climate risks and opportunities · Insurance industry · Firm value

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Introduction

Climate risks are becoming increasingly important for insurance companies. For instance, Munich Re estimates an economic impact of USD 160 billion due to natural disasters for 2018, with only 50% being insured,[1] and the Allianz Risk Barometer 2019 ranks natural disasters (3) and climate change (8) among the top 10 global business risks.[2] At the same time, opportunities include an increase in insurance demand or product and service innovation, for example (see, e.g. Maynard 2008; Mills 2009; Stechemesser et al. 2015). Though there is an extensive literature on the insurance industry and climate change that focuses on risks and/or opportunities (for a literature review, see, e.g. Stechemesser et al. 2015), only a few studies present empirical findings in this context. Thus, the aim of this paper is to contribute to previous work by empirically identifying drivers behind the awareness of European and U.S. insurance companies of the business risks and opportunities resulting from climate change using a respective indicator from the Refinitiv Eikon database. To the best of our knowledge, this has not been done so far. We further extend previous research by studying the value effects of this awareness for a broad panel dataset.

The literature review and empirical analysis by Stechemesser et al. (2015) appears to be the only study on the adaptation of insurance companies to climate change and its influence on corporate financial performance for firm data for the year 2009. The authors build their approach on Mills (2009), who identifies 10 categories for adapting to and initiating countermeasures against climate change. Mills (2009) also discusses long-term-related best practices (e.g. risk model enhancement) and presents short-term-related first moves (e.g. understanding climate change as an enterprise risk management case).[3] Based on a content analysis of insurers' Carbon Disclosure Project responses, Stechemesser et al. (2015) find that adaptations to climate change and return on assets are positively related, but they do not give further investigation to the causal relationship.

Further insurance-related publications focus on the impact, revision, potentials and shortcomings of the ClimateWise Principles since their introduction in 2007 (see Jones and Phillips 2016)[4] as well as on analysing the results from the 2012 and 2015 Climate Risk Disclosure Survey in the U.S. With regard to the latter, Thistlethwaite and Wood (2018) conclude that overall only a few U.S. insurers make adjustments in order to implement a climate change risk management

[1] https://www.munichre.com/topics-online/en/climate-change-and-natural-disasters/natural-disasters/the-natural-disasters-of-2018-in-figures.html, accessed 09/12/2019.

[2] https://www.agcs.allianz.com/content/dam/onemarketing/agcs/agcs/reports/Allianz-Risk-Barometer-2019.pdf, accessed 09/12/2019.

[3] The measures include the reduction of greenhouse gas emissions or sustainability-related product adjustments. More than 300 documents as well as responses from a survey distributed among insurers make up the database of this analysis (see Mills 2009).

[4] The ClimateWise initiative consists of members from the global insurance industry. It is a cooperative platform that facilitates its members to address the direct and indirect repercussions of climate change, and requests reporting in line with the six ClimateWise Principles and further sub-principles at the same time (see Jones and Phillips 2016).

(CCRM) in their asset management, insurance business and management. The 2015 survey also shows that a greater share of reinsurers has an integrated CCRM compared to primary insurers. Damert and Baumgartner (2018) focus on the automotive industry and present findings on the determinants of corporate action on climate change based on nine activities and their implementation status. By using an OLS regression model, the authors highlight intracompany factors, such as integration into risk management, and the property of being a B2C-business as major drivers, which might be of relevance for insurance companies as well. In addition, Lee (2012) studies six different corporate carbon strategies applied by 241 South Korean companies from a broad range of sectors. While the results show a significant relationship between size and the corporate carbon strategies based on an analysis of variance (ANOVA), this cannot be concluded for corporate performance. Thus, a current analysis of the drivers and value effects of considering climate change-related risks and opportunities over time in the insurance business has not yet been conducted, and specifically not for an extensive panel dataset from different regions.

Against this background, our objective is to fill this gap and to contribute to the current climate change literature. Our sample consists of 50 publicly-listed insurance companies from the U.S. and Europe. We identify insurance companies that have managed commercial risks and opportunities resulting from climate change over 10 years (2009–2018) by reverting to a corresponding indicator from the commonly applied Refinitiv Eikon database. Based on this, we use a logistic regression to determine the drivers of insurers' consideration of climate change-related risks and opportunities, including firm characteristics such as size or region. This model is also commonly applied in the risk management literature with the aim of identifying differences between adopters and non-adopters of a specific approach such as enterprise risk management (ERM) (see, e.g. Bohnert et al. 2019a) or reputation risk management (see Heidinger and Gatzert 2018). Value effects are studied based on Tobin's Q as a proxy for firm value. Endogeneity may pose a problem in this context, e.g. due to omitted variables or because factors simultaneously influence the decision to consider climate change risks and opportunities in the insurance business as well as firm value. Thus, we make use of a fixed effects regression model and control for non-observable firm characteristics. We further address potential endogeneity issues in supplementary analyses, which include a two-step approach with instrumental variables (see Liebenberg and Sommer 2008; Wooldridge 2010; Hoyt and Liebenberg 2011; Sassen et al. 2016; Bohnert et al. 2019a).

Our results show that larger property & casualty insurers from Europe are significantly more likely to manage climate change-related risks and opportunities. We also find a statistically significant positive impact on firm value based on a linear fixed effects model. Our findings are also of high practical relevance for insurers, given that climate-related public and regulatory pressure will continue to intensify in the future.

The remainder of this paper is structured as follows. The next section provides the data, methodology and hypotheses development. The empirical results are presented in the subsequent section, and the final section summarises the results.

Data, methodology and hypotheses development

Data sample

To establish the sample, we select all U.S. firms as well as firms located in the European Union (including the U.K.), hereafter referred to as European, in the Refinitiv Eikon database from the Thomson Reuters Business Classification (TRBC) sector 'Insurance' with emitted ordinary shares and an obtainable market capitalisation in Thomson Reuters Datastream at the end of 2018. To identify the determinants and value of considering climate change-related risks and opportunities in the European and U.S. insurance industry from 2009 to 2018, we use the indicator 'Climate Change Commercial Risks Opportunities' (ClimateRO) retrieved from the Refinitiv Eikon environmental, social and governance (ESG) database. The indicator takes the value of 1 if the company is 'aware that climate change can represent commercial risks and/or opportunities', which Refinitiv Eikon describes as follows in their database 'development of new products/services to overcome the threats of climate change to the existing business model of the company—some companies take climate change as a business opportunity and develop new products/services'.[5]

We exclude all firms without complete indicator data over the sample period as well as several firms after having reviewed their business descriptions in annually published reports.[6] This procedure leads to 29 U.S. and 21 European insurance companies with a total market capitalisation of USD 752 billion, corresponding to 48.0% of the market capitalisation of the initial sample. The resulting firm sample is summarised in Table 1 and the considered insurance companies are presented in Table 6 in the Appendix.

Figure 1 shows the number of firms in the sample with a ClimateRO indicator of 1 by region. One can see that the overall number of insurers that are aware that climate change can pose risks and opportunities to their business model increases over time from 24 out of 50 (or 48.0%) in 2009 to 35 firms (or 70.0%) in 2018. This is also in line with the numbers from the global Asset Owners Disclosure Project & ShareAction (AODP&SA 2018, p. 5) report, which states that '[m]ore than two thirds (69%) of the assessed insurers were able to disclose financially material

[5] For each firm-year-related positive indicator, Refinitv Eikon offers information on the name of the source and publisher, a link and a date as well as an abstract, which includes the relevant passage in the text for the decision. Based on an available data collection policy, typical sources are annual and sustainability reports, as well as Carbon Disclosure Project reports from publicly available websites. Also, if companies no longer report on their awareness despite having previously done so, Refinitiv Eikon keeps the indicator at 1 (yes) for up to two years, before setting it to 0 (no). We also note that Refinitiv Eikon updates its ESG database for previous years, which may result in adjustments to the indicator and ESG data in general. Table 5 in the Appendix illustrates the rating approach and the documentation, with two examples showing a positive ClimateRO indicator.

[6] We exclude two conglomerates (Berkshire Hathaway Inc. and Loews Corp), four insurance brokers (Aon PLC, Brown & Brown Inc., Arthur J Gallagher & Co. and Willis Towers Watson PLC) and one firm due to a past merger (UnipolSai Assicurazioni SpA). A major market share reduction within our sample is based on the Berkshire Hathaway Inc. exclusion (2018: USD 502 billion market capitalisation; 32.0% of the initial sample).

Table 1 Sample derivation procedure

Sample creation (and exclusions)	Market capitalisation (incl. respective share)	Number of firms		
		Total	U.S.	European
Total European and U.S. insurers in Refinitiv Eikon with emitted ordinary shares and obtainable market capitalisation at the end of 2018 in Datastream	USD 1567 billion (100.0%)	149	88	61
After excluding firms with missing Refinitiv Eikon indicator data for the whole sample period 2009–2018	USD 1351 billion (86.2%)	57	33	24
After excluding firms, e.g. due to their business focus (conglomerate, merger, broker)	USD 752 billion (48.0%)	50	29	21

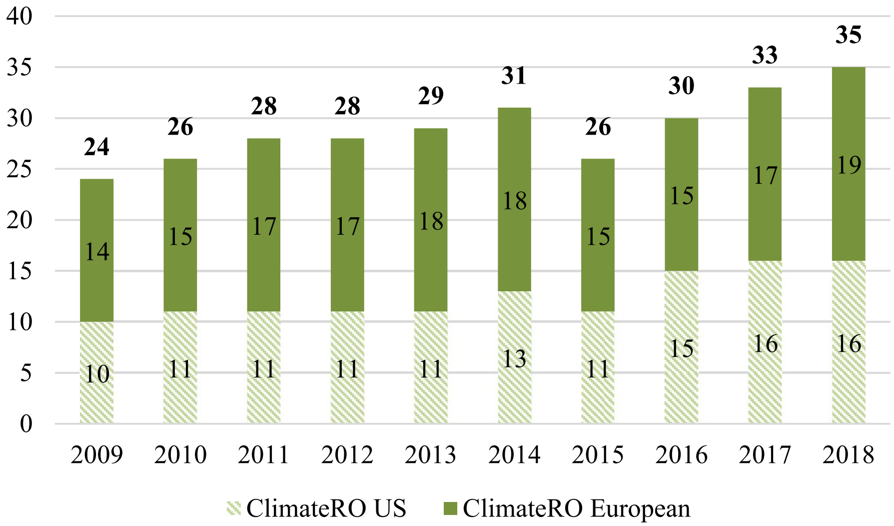

Fig. 1 Number of European and U.S. insurers in the sample (i.e. out of 50, 29 U.S. and 21 European insurers) that are aware of the commercial risks and opportunities associated with climate change based on the Refinitiv Eikon indicator (ClimateRO = 1)

climate-related risks but only 41% were able to identify business opportunities'. European firms almost always represent the majority within the sample for each year of the sample period, with 19 out of 21 being aware in 2018, compared to 14 in 2009. By comparison, around one third of U.S. insurers in the sample consider climate risks and opportunities in 2009, increasing to 16 out of 29 (around half) in 2018.

We also observe variations in the database concerning the identified individual insurance companies with ClimateRO = 1 over time. For instance, five insurers change their indicator from 1 to 0 in 2015. The increase to 35 firms with ClimateRO = 1 in 2018 is then mainly driven by newly identified insurers, as only one of the five aforementioned insurers is reinstated as being aware of these risks and opportunities. One possible explanation for the variation might be the then applied and already mentioned Refinitiv Eikon data collection approach, which defines the data basis and measures for the case of missing data.

In general, the use of the indicator also imposes restrictions and potential limitations. For instance, it only represents an approximate measure of awareness of commercial climate change-related risks and opportunities instead of a detailed analysis of subindicators and multiple dimensions as used in e.g. Stechemesser et al. (2015) for their single year analysis. In addition, as noted earlier, Refinitiv Eikon may retrospectively update its ESG data based on newly identified information, which may also cause adjustments in the indicator and which is a general issue with all empirical ESG studies. However, given the large panel with 500 firm-year observations, a manual analysis would be more prone to error. Moreover, the database is commonly applied in research and, as already mentioned above, has a data collection policy in place representing a standardised procedure.

Hypotheses development and empirical methodology

Empirical methodology and hypotheses development for determinants of awareness of climate risks and opportunities

To study the determinants of awareness of climate risks and opportunities, we use the previously presented *ClimateRO* indicator as the dependent variable and next derive our hypotheses concerning the impact of firm attributes as determinants of this awareness in U.S. and European insurers. The calculations of the examined variables are based on Bohnert et al. (2019a, b) and the data are retrieved from Thomson Reuters Datastream and Refinitiv Eikon.

Size Although climate change affects all social ranks and corporate structures, we assume that larger insurance companies tend to be more aware of climate risks and opportunities due to greater exposure based on e.g. larger investment/underwriting portfolios and/or broader (regional) diversification. As pointed out in the ERM literature, larger firms, and insurance companies in particular, are also exposed to a growing number of and more complex risks compared to small and medium-sized enterprises (see Gatzert and Martin 2015), which include climate change.[7] Moreover, larger firms presumably adopt a more sophisticated corporate social responsibility (CSR) concept, including the management of climate risks and opportunities, due to greater financial scope and human resources (see Menz 2010; Weinhofer and Hoffmann 2010) as well as greater focus of public interest (see e.g. Fombrun and Shanley 1990; Chih et al. 2010). In line with this, the empirical literature on issues related to climate change finds a significant positive relation for firm size (see e.g. Lee 2012; Yunus et al. 2016; Damert and Baumgartner 2018). Overall, we therefore expect a positive relationship between *Size* and *ClimateRO*, where *Size* is measured as the natural logarithm of the (book value of) total assets (WC02999).

Leverage Various papers find a negative relation between leverage and the sustainable actions of companies (see McGuire et al. 1988; Waddock and Graves 1997a, b; Barnea and Rubin 2010), while Sharfman and Fernando (2008) find a significant positive relation, which they explain by assuming that firms with enhanced environmental risk management are less risky, thus allowing greater leverage. Yunus et al. (2016) suggest that companies that are more reliant on debt capital tend to comply with creditors' opinions on climate change-related issues and adopt a carbon management strategy. Their panel data analysis shows a significant positive relation for Australian firms in this context. In addition, a holistic risk management approach that includes the management of climate risks and opportunities in the underwriting and investment portfolio may reduce risks and facilitate access to debt capital. Against

[7] For instance, Mills (2009) suggests considering climate change as an ERM case. Moreover, Carney (2015) perceives climate change as a threat to financial stability through physical, liability and transition risks and it is also increasingly understood as a key matter of business at the firm level (see The Geneva Association 2018).

this background, the relation between *Leverage* and *ClimateRO* is ambiguous. We calculate *Leverage* by dividing a firm's book value of liabilities as the difference between total assets (WC02999) and total shareholders' equity (WC03995) by its market value of equity (=market capitalisation—WC08001).

Slack Following the considerations in the ERM and climate change literature, firms being aware of climate risks and opportunities may have increased financial slack in order to decrease the hazard of financial distress resulting from climate risks on the one hand. On the other hand, awareness might also allow them to lower financial slack due to enhanced (climate) risk management (see Pagach and Warr 2010; Hoyt and Liebenberg 2011; Huang et al. 2018; Bohnert et al. 2019a). Overall, we expect an ambivalent relation between *ClimateRO* and *Slack* and define the latter as the ratio of cash as well as short-term investments (=cash & equivalents generic—WC02005) and (book value of) total assets (WC02999).

Europe Along with climate risks and opportunities, CSR and sustainability have become increasingly important in Europe since the European Commission (2001, 2010, 2011) first published its Green Paper on promoting CSR in Europe in 2001. This increasing relevance is also reflected in the subsequent introduction of the EU Directive 2014/95/EU in 2017, where the European Parliament and Council (2014, 2016) aim to enhance data availability and transparency through improved corporate reporting of certain large-sized firms on non-financial information, including environmental and social factors. In addition, the EU Directive 2016/2341, inter alia, regulates the integration of ESG issues in the investment and risk management process of pension funds and life insurers as institutions for occupational retirement provision (IORPs), also with specific references to climate change aspects. In the U.S., the SEC (2010) provides guidance on disclosing climate change-related information within the existing disclosure regulation.[8] However, Thistlethwaite and Wood (2018) observe, based on U.S. Climate Risk Disclosure Survey data from 2012 and 2015, that the majority of property insurers do not manage climate change risk thoroughly, and the AODP&SA (2018) survey on climate-related financial disclosure reveals that U.S. insurers represent the 'laggards' among an international sample while European insurers act as 'leaders'. Furthermore, by referring to measures concerning norms on environmental and social matters, Dyck et al. (2019) conclude that a large gap exists between the U.S.—with relatively low social standards—and several European countries as frontrunners. We thus expect that, overall, European insurers are more likely to be aware of climate change-related risks and opportunities than U.S. insurers, where a value of 1 is used for European firms and 0 for U.S. firms.

[8] See also e.g. Camilleri (2017) or Berger-Walliser and Scott (2018) for an overview on CSR in the U.S., including climate change and regulation, as well as Ciocirlan and Pettersson (2012) for a discussion on climate change-related differences between the EU and U.S. with a focus on the first decade of the 21st century. In line with their hypotheses, they also find a significant positive relation between presence in EU countries and the management of climate change issues for their sample of Fortune 500 companies.

The resulting model aims to explain the influence of the determinants presented above on an insurer's decision to consider climate risks and opportunities and can thus be described by

$$ClimateRO = f(Size, Leverage, Slack, Europe). \quad (1)$$

In line with the (climate) risk management literature (see e.g. Liebenberg and Hoyt 2003; Yunus et al. 2016; Heidinger and Gatzert 2018), we apply a logistic regression to analyse the determinants. The binary logistic regression considers all 500 firm-year observations of the presented variables, including dummy variables to control for the impact of year effects

$$\ln\left(\frac{p(ClimateRO = 1)}{1 - p(ClimateRO = 1)}\right) = \beta_1 Size + \beta_2 Leverage + \beta_3 Slack + \beta_4 Europe + \beta_{5-13} Year + \varepsilon, \quad (2)$$

where *ClimateRO* represents the dependent variable. By applying the natural logarithm on an insurer's probability to consider climate risks and opportunities divided by the converse probability, one can calculate the odds ratio. Intragroup correlations pose an issue as our data consists of multiple observations per firm, i.e. 10 observations for each of the 50 sample firms. However, we expect a lack of intergroup correlations, i.e. independent observations between firms. Due to the panel structure, we adjust standard errors for firm-level clustering (robust standard errors) (see Wooldridge 2010; Hilbe 2017; Heidinger and Gatzert 2018; Bohnert et al. 2019a).

Empirical methodology and hypotheses development for the value effect of being aware of climate risks and opportunities

We further study the value-relevance of being aware of climate change-related risks and opportunities by studying the relationship between *ClimateRO* and Tobin's Q (Q). We calculate Q[9] by dividing the sum of the market value of equity (=market capitalisation—WC08001) and the book value of liabilities by the (book value of) total assets (WC02999). The book value of liabilities is calculated by the difference between total assets (WC02999) and total shareholders' equity (WC03995) (see e.g. Bohnert et al. 2019b).

It is reasonable to use Q as a forward-looking performance measure reflecting investors' prospects for the respective firm (see Hoyt and Liebenberg 2011), because climate change potentially affects insurers' assets, liabilities and corporate strategy over both the short and long term (see Herweijer et al. 2009; Gatzert et al. 2020). Moreover, competitive disadvantages as well as litigation, reputation, insurance and financial risks can emerge from inadequate corporate actions against climate change (see Busch and Hoffmann 2007; Damert and Baumgartner 2018, p. 476; Gatzert et al. 2020). Changes in market dynamics can even result in uninsurable risks (see

[9] Following Cummins et al. (2006) and Hoyt and Liebenberg (2011), this derivation of Q is applicable for insurers or financial firms in general, as replacement costs and the book value of assets generally converge.

IAIS 2018) as well as in new opportunities through, e.g. new product development or higher insurance demand.[10] The value-relevance of considering climate risks and opportunities also becomes apparent from increasing efforts towards enhanced corporate transparency on climate-related financial information and data, as done by the Task Force on Climate-related Financial Disclosures (TCFD 2017) or the Carbon Disclosure Project. In line with these arguments, Stechemesser et al. (2015) find a significant positive relation between adaptations to climate change and the return on assets based on insurers' Carbon Disclosure Project responses for the year 2009.

Against this background, we expect that awareness of climate change-related risks and opportunities has a positive impact on firm value, and use a panel data regression model to assess the value-relevance of *ClimateRO*. Based on the results of a Lagrange multiplier test for random effects, introduced by Breusch and Pagan (1980), and a robust version of the Hausman test (see Schaffer and Stillman 2010), we apply a linear fixed effects regression model. Our approach is in line with other studies in the context of reputation risk management (see Heidinger and Gatzert 2018) and the ESG literature (see Sassen et al. 2016). As we study a panel dataset with multiple observations per insurance company, it is possible that firms switch between the ClimateRO group and non-ClimateRO group (see also Fig. 1 and the related explanations). The data thus comprises 500 firm-year observations in total, 290 of which correspond to firms that are aware of commercial risks and opportunities related to climate change and 39 different insurance companies out of 50 firms exhibit a positive *ClimateRO* indicator at least once during the sample period. The remaining 210 firm-year observations with $ClimateRO=0$ include 33 different insurance companies. Based on the summary of the within percentage, for the 39 (33) firms with at least one observation of $ClimateRO=1$ ($ClimateRO=0$), 74% (64%) of their observations are $ClimateRO=1$ ($ClimateRO=0$), i.e. consider (do not consider) these risks and opportunities. Besides firm fixed effects, and in line with Sassen et al. (2016), additional testing of model assumptions leads to the application of robust standard errors clustered at the firm level and time (or year) fixed effects.

Besides considering *ClimateRO* as a major independent variable, we further consider a number of other commonly applied independent variables for firm value. Hoyt and Liebenberg (2011) and Bohnert et al. (2017) provide an extensive review of firm value determinants in this context (see also Bohnert et al. 2019a, b). Thus, in addition to the already defined firm characteristics *Size* and *Leverage*, the three independent variables *Return on Assets* (*ROA*), *Dividends* and *SalesGrowth* are added to the regression analysis. While *ROA* is calculated by dividing the net income (= net income available to common—WC01751) by the book value of assets (= total assets—WC02999), the *Dividends* variable represents a dummy variable that takes a value of 1 for paid dividends (= cash dividends paid total—WC04551) in year *t* and

[10] See Stechemesser et al. (2015) for an extensive literature review on climate change adaptation in the insurance industry, including, but not limited to, the aforementioned risks and opportunities, the Geneva Association (2018) report by M. Golnaraghi with insights from insurance practice and on (missing) efforts to combat climate change, and Gatzert et al. (2020) for an overview of sustainability risks and opportunities (including climate change issues) in the insurance industry.

0 otherwise. *SalesGrowth* is the difference between net sales or revenue (WC01001) in year t and in year $t-1$ divided by net sales or revenue in $t-1$ (again, for variable definitions see Bohnert et al. 2019a, b). Overall, this approach leads to the following model:

$$Q_{it} = \alpha_i + \beta_1 ClimateRO_{it} + \beta_2 Size_{it} + \beta_3 ROA_{it} + \beta_4 Leverage_{it} + \beta_5 Dividends_{it} + \beta_6 SalesGrowth_{it} + \beta_{7-15} Year_t + u_{it} \quad (3)$$

Empirical results for determinants and value effects of awareness of climate risks and opportunities

In the following, we first present bi- and univariate results for the determinants and value effects, starting with the Pearson's and Spearman's correlation coefficients in Table 7 in the Appendix, where we can already see strong significant relations between the variables, in line with our hypotheses. With respect to the determinants of awareness of climate change-related risks and opportunities, we observe significant positive correlations between *ClimateRO* and *Size*, *Leverage* and *Europe*, and a significant negative one with *Slack*. For value, we find a significant negative relation between *Q* and *Size* and *Leverage*, and a significant positive relation with *ROA* and *SalesGrowth* (in terms of the Spearman's correlation coefficient), while the correlation between *ClimateRO* and *Q* is rather ambiguous. The Pearson's correlation coefficient is negative and not significant. However, in line with our expectations, we find a weak positive Spearman's correlation coefficient that is statistically significant at the 10% level.[11]

When considering the group differences in means and medians in Table 2, we again find ambiguous results concerning the differences of *Q*. While we do not see a statistically significant difference in mean with respect to firm value for firms with and without an awareness of climate risks and opportunities, the statistically significant difference in median indicates that the group with such awareness shows a slightly higher firm value (a difference value of 0.0003, statistically significant at the 10% level). Note that the *Q* value is higher than 1 for both groups. Moreover, we do observe significantly different characteristics between the groups, as firms with $ClimateRO = 1$ are significantly larger, have a lower *ROA* (in terms of median), are more leveraged, exhibit smaller financial slack, tend to pay dividends and are based in Europe. We do not find statistically significant differences concerning *SalesGrowth*. Thus, we next turn towards our logistic regression and fixed effects model to further examine the determinants and value effects.

[11] As the (absolute) correlation coefficients between the independent regression variables do not exceed 0.8 (with correlations of 0.76/− 0.79 between *Leverage* and *Size*/*ROA*), multicollinearity should not pose a problem (see Mason and Perreault 1991). In addition, the variance inflation factors remain below a threshold value of 10 (see Marquardt 1970).

Table 2 Differences in means and medians for the ClimateRO group and non-ClimateRO group

	ClimateRO = 1 (290 firm-year observations)		ClimateRO = 0 (210 firm-year observations)		Difference	
	Mean	Median	Mean	Median	In means	In medians
Q	1.101	1.015	1.129	1.015	– 0.028	0.0003*
Size	18.377	18.462	16.796	16.763	1.581***	1.699***
ROA	0.016	0.009	0.020	0.015	– 0.004	– 0.006***
Leverage	12.193	7.088	6.198	3.849	5.995***	3.239***
Slack	0.025	0.019	0.036	0.025	– 0.011***	– 0.006***
Dividends	0.900	1.000	0.848	1.000	0.052*	0.000*
SalesGrowth	0.013	0.018	0.034	0.022	– 0.021	– 0.004
Europe	0.569	1.000	0.214	0.000	0.355***	1.000***

500 firm-year observations. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. A two-sample *t* test represents the basis for statistical significance of differences in means. A non-parametric Wilcoxon rank-sum test is performed for statistical significance of differences in medians. A chi-square-test for dummy variables and an equality-of-medians test for the other variables are performed in addition. With regard to these two tests, *Size*, *ROA*, *Leverage*, *Slack* and *Europe* show statistically significant results at the 1% level and *Dividends* at the 10% level

Table 3 Logistic regression results for the determinants of awareness of climate risks and opportunities (*ClimateRO*)

	Hypothesised relation	Parameter estimate (β)	Robust standard error	Wald	Exp(β)/odds ratio
Size	+	0.814***	0.195	17.306	2.256†
Leverage	±	– 0.020	0.023	0.810	0.980
Slack	±	– 0.056	6.521	0.000	0.946
Europe	+	1.380**	0.594	5.382	3.977†
Intercept		– 14.734***	3.473	17.978	0.000†

ClimateRO represents the dependent variable. Dummy variables are considered to control for year effects without being depicted in the table. Robust standard errors are included (clustering at firm-level). Statistical significance is reported at the 1%, 5% and 10% levels and is denoted by ***, ** and *, respectively. Sample consists of 500 firm-year observations

†The 95% confidence interval does not include the value of 1 (equivalent to statistical significance at the 5% level) (see Mehmetoglu and Jakobsen 2017)

With *ClimateRO* representing the dependent variable, we next study the influence of firm characteristics on the insurers' awareness of climate risks and opportunities using a multivariate logistic regression model that also considers year effects

Table 4 Linear fixed effects model regarding the value effect of *ClimateRO*

Variable	Coefficient	Robust standard error
ClimateRO	0.090**	0.035
Size	− 0.480*	0.254
ROA	1.602	1.228
Leverage	0.002	0.003
Dividends	0.088	0.093
SalesGrowth	− 0.012	0.025
Intercept	9.345**	4.385
Number of observations	500	
Number of firms	50	
R-squared (within)	0.392	

Q represents the dependent variable. Besides robust standard errors (clustering at firm-level), firm and year fixed effects (not reported) are included. An additional least squares dummy variable regression shows a R-squared value of 0.752. Statistical significance is reported at the 1%, 5% and 10% levels and is denoted by ***, ** and *, respectively

in Table 3.[12] In line with our hypotheses, the results show that larger insurers from Europe—all else being equal—are significantly more likely to be aware of climate risks and opportunities, as reflected in the indicator *ClimateRO*.[13] In contrast to our expectations, all other variables do not exhibit significant effects. When including the four subsectors *property & casualty* (*PC*), *life & health* (*LH*), *multiline* (*ML*) and *reinsurance* (*REI*) as dummy variables,[14] the results show that *PC* and *ClimateRO* are significantly positively related (parameter estimate = 1.622, p value = 0.063; i.e. statistical significance at the 10% level) while other relationships remain unchanged.[15]

Besides controlling for subsectors, we also run an additional analysis by including *ROA* and *Dividends* in Eq. (2) as these two variables show significant results in the group differences analysis. While the results remain unchanged for the former variables, *ROA* shows a positive relation (parameter estimate = 12.990, p value = 0.116) and *Dividends* is negatively related (parameter estimate = − 0.734, p value = 0.233) to *ClimateRO*. However, the analysis indicates that the variables

[12] Besides model specification tests confirming the suitability of our models (see e.g. Long and Freese 2014; Mehmetoglu and Jakobsen 2017), including the consideration of year dummies, the calculation of the Pseudo R-squared shows a value of 0.260, which is in line with values in other studies (see e.g. Beasley et al. 2005; Bohnert et al. 2019a). We further identify potential influential firm-year observations based on Pregibon's dbeta as well as based on standardised residuals and examine their influence (see e.g. Long and Freese 2014; Mehmetoglu and Jakobsen 2017).

[13] The exp(β) (odds ratio) value of 2.256 for *Size* implies that an increase in firm size by one unit—all else being equal—increases the relative probability of *ClimateRO* = 1 by 125.6% (2.256–1.000 = 1.256) (see Long and Freese 2014; Mehmetoglu and Jakobsen 2017).

[14] The *REI* dummy is then omitted due to collinearity.

[15] The p value for *Europe* changes to 0.005 (statistical significance at the 1% level). When excluding potential influential observations, the results are robust. *PC* still shows a significant positive relation, but now at the 5% level instead of the 10% level.

do not represent significant determinants of the awareness of climate change-related risks and opportunities.[16]

Next, the results of the linear fixed effects model are presented in Table 4. In line with our expectations, we find a positive and statistically significant effect of *ClimateRO* on Tobin's *Q* at the 5% level while controlling for other variables, as well as for unobservable firm characteristics and year effects. In contrast, *Size* shows a significant negative coefficient.

In line with the risk management literature (see e.g. Hoyt and Liebenberg 2011; Heidinger and Gatzert 2018), an additional robustness test is conducted by excluding *Dividends* and *SalesGrowth* from the model and only considering *Size*, *ROA* and *Leverage* as the most prevalent control variables in the context of Tobin's *Q*. Our results are robust as we do not find changes in relations or significance levels (*ClimateRO*: regression coefficient = 0.092, *p* value = 0.011; *Size*: − 0.477, *p* value = 0.067).

Besides reducing the model to key control variables, we also add *Slack* from the determinants in Eq. (2) to the value model in Eq. (3), as omitting this variable might cause the omitted variable bias. While our results do not change for *Leverage*, *Dividends* and *SalesGrowth*, we find relevant changes in the significance level for *ClimateRO* (*p* value = 0.006), *Size* (*p* value = 0.018) and *ROA* (*p* value = 0.027) as well as a significant positive relation between *Slack* and *Q* at the 1% level (regression coefficient = 6.167, *p* value = 0.000).[17] We further challenge the application of the linear fixed effects estimation by using an instrumental variables approach instead, which is generally in line with Cheng et al. (2014) and Aouadi and Marsat (2018), in that we make use of e.g. the average CSR or ESG performance while excluding the performance of the focal firm, retrieved from Refinitiv Eikon. However, we create two different (subsector-year and region-year) combinations instead of using an industry-year combination, for instance. While these two variables, i.e. *ESGMSubYear* and *ESGMRegYear*, represent the instruments in the model with firm fixed effects, we use *Europe* (time-invariant) together with *ESGMSubYear* as instruments in the model without firm fixed effects. An endogeneity test based on a two-step feasible generalised method of moments (GMM) estimation is not significant for both considered models with and without firm fixed effects, implying that there is no support that the regressor *ClimateRO* is endogenous based on this modelling and estimation approach. Overall, based on the additional analyses with instrumental variables, we conclude that the linear fixed effects estimation in Eq. (3) is more efficient in the present context.[18]

[16] We again check potential influential firm-year observations and find that *ROA* is significantly positively related at the 10% level in the context of the dbeta analysis and *Europe* at the 1% level in the context of the standardised residuals analysis, while other results remain unchanged.

[17] By adding *Slack* to Eq. (3), the *R-squared* from the least squares dummy variable regression shows a value of 0.859, while the *R-squared (within)* value increases to 0.655 in comparison to Table 4.

[18] The application of two instruments allows for validity and relevance checks. The results of these checks, apart from the non-significant endogeneity test, also indicate that weak instruments might represent an issue, especially in the model with firm fixed effects. We thus also use a robust version of the LIML estimator, also referred to as the 'continuously updated' GMM estimator (CUE) (see Baum et al. 2007), to address this issue, as also suggested by Greene (2020). It confirms our conclusions.

We thus get a first indication of the value-relevance of considering climate change-related risks and opportunities in the insurance business while controlling for multiple firms and years, as well as addressing potential endogeneity.

Summary

The aim of this paper is to empirically study the awareness of the European and U.S. insurance industry with regard to climate change-related risks and opportunities. This has not been the focus of the literature so far, even though the topic is of high relevance for insurers, who also face increasing pressure from regulatory and public initiatives to take action against climate change. We use logistic regression analysis as well as a linear fixed effects model to determine the drivers and value effects of awareness of climate change-related risks and opportunities over 10 years from 2009 to 2018. The awareness is captured by using an indicator from the Refinitiv Eikon database. The indicator shows an increasing awareness among U.S. and European insurers, as reflected in public reports. While almost half of the 50 firms in the sample consider climate change-related risks and opportunities to some extent in 2009, the portion increases to more than two thirds by 2018, with the majority being located in Europe.

Our analysis of group differences also suggests that insurers with and without climate change awareness significantly differ in terms of firm characteristics. The logistic regression confirms our assumed relations for the determinants, in that larger insurers situated in Europe are significantly more likely to be aware of climate risks and opportunities. When controlling for insurance subsectors as well as other potential determinants, we find a significant positive relation for property & casualty insurers. A possible explanation could be that this subsector accepts its particular exposure to an increasing number of severe natural disasters. However, this does not exclude the other subsectors; for instance, the life & health subsector represents a long-term investor that is also confronted with transition and physical risks as well as life and health issues from climatic deterioration. Our regression results also indicate that firms with such awareness do not show higher or lower leverage and slack resources.

In line with the literature, the linear fixed effects model shows a significant positive effect of our indicator for the awareness of climate risks and opportunities on Tobin's Q as proxy for firm value. Besides our fixed effects model, which already addresses endogeneity to a certain extent, we additionally apply an instrumental variables approach. We conclude in this context that our initial estimation represents the preferential strategy. Future research could focus on different regions and industries, or study different measures of climate risk awareness. Moreover, the increasing implementation of the TCFD (2017) recommendations might have a possible (future) impact on firm value.[19]

Appendix

See Tables 5, 6, and 7.

[19] See AODP&SA (2018) for more information on the global insurance sector's TCFD (2017) implementation.

Table 5 Selected examples of background information in Refinitiv Eikon for positive ClimateRO indicators

Firm:	Markel Corporation
Considered in Year:	2018 [Note: Published for 2016 and considered in 2018]
Published on:	24-Feb-2017
Excerpt from Form 10-K 2016 (p. 24)	We may experience losses from catastrophes. As a property and casualty insurance company, we may experience losses from man-made or natural catastrophes. Catastrophes may have a material adverse effect on operations. Catastrophes include, but are not limited to, windstorms, hurricanes, earthquakes, tornadoes, hail, severe winter weather and fires and may include events related to terrorism and political unrest. While we employ catastrophe modeling tools in our underwriting process, we cannot predict how severe a particular catastrophe will be before it occurs. The extent of losses from catastrophes is a function of the total amount of losses incurred, the number of insureds affected, the frequency and severity of the events, the effectiveness of our catastrophe risk management program and the adequacy of our reinsurance coverage. Most catastrophes occur over a small geographic area; however, some catastrophes may produce significant damage in large, heavily populated areas. If, as many forecast, climate change results in an increase in the frequency and severity of weather-related catastrophes, we may experience additional catastrophe-related losses, which may be material
Link:	https://www.sec.gov/Archives/edgar/data/1096343/000109634317000046/mkl_12312016x10k.htm
Firm:	Unipol Gruppo SpA
Considered in Year:	2018
Published on:	15-Mar-2019
Excerpt from Integrated Consolidated Financial Statements 2018 (p. 64)	CLIMATE CHANGE Climate change, greenhouse gas emissions, biodiversity, food production, spread of new diseases, resistance RISKS Failure to incorporate impacts in terms of the growing exposure to extreme weather events into pricing. OPPORTUNITIES Contribution to the creation of a mixed public/private system. Creation of products that incentivise prevention and responsible behaviours. Offering prevention and disaster recovery consulting services. Campaigns of commitment in favour of the climate and environmentally responsible business policies. GROUP RESPONSES Reducing and optimising direct environmental impacts (ISO 50001). Derris Project. Climate guarantees. Incentives in the pricing of policies of virtuous policyholder environmental conduct
Link:	http://www.unipol.it/sites/corporate/files/document_attachments/bilancio_consolidato_integrato_2018_ug_def_eng_0.pdf

Table 6 List of insurance companies included in the sample

Admiral Group PLC	Mapfre SA
Aegon NV	Markel Corp
Aflac Inc	MBIA Inc
Ageas SA	Mercury General Corp
Alleghany Corp	MetLife Inc
Allianz SE	MGIC Investment Corp
Allstate Corp	Muenchener Rueckversicherungs Gesellschaft AG in Muenchen
American Financial Group Inc	Old Republic International Corp
American National Insurance Co	Progressive Corp
Assicurazioni Generali SpA	Prudential Financial Inc
Aviva PLC	Prudential PLC
AXA SA	Radian Group Inc
Beazley PLC	Reinsurance Group of America Inc
Cincinnati Financial Corp	RSA Insurance Group PLC
CNA Financial Corp	Sampo plc
CNP Assurances SA	Scor SE
Erie Indemnity Co	Societa Cattolica di Assicurazione Sc
Fidelity National Financial Inc	Topdanmark A/S
Genworth Financial Inc	Travelers Companies Inc
Globe Life Inc	Tryg A/S
Hannover Rueck SE	Unipol Gruppo SpA
Hanover Insurance Group Inc	Unum Group
Hartford Financial Services Group Inc	Vienna Insurance Group AG Wiener Versicherung Gruppe
Kemper Corp	W. R. Berkley Corp
Lincoln National Corp	White Mountains Insurance Group Ltd

Table 7 Correlation coefficients for examined variables (Pearson and Spearman Rho)

		Q	*ClimateRO*	*Size*	*ROA*	*Leverage*	*Slack*	*Dividends*	*Sales Growth*	*Europe*
Q	Pearson	1								
	Spearman Rho	1								
ClimateRO	Pearson	− 0.037	1							
	Spearman Rho	0.082*	1							
Size	Pearson	− 0.381***	0.484***	1						
	Spearman Rho	− 0.331***	0.482***	1						
ROA	Pearson	0.566***	− 0.058	− 0.354***	1					
	Spearman Rho	0.578***	− 0.168***	− 0.550***	1					
Leverage	Pearson	− 0.260***	0.262***	0.595***	− 0.325***	1				
	Spearman Rho	− 0.691***	0.253***	0.762***	− 0.790***	1				
Slack	Pearson	0.638***	− 0.151***	− 0.325***	0.271***	− 0.159***	1			
	Spearman Rho	0.161***	− 0.121***	− 0.235***	0.083*	− 0.183***	1			
Dividends	Pearson	0.064	0.079*	0.213***	0.095**	− 0.063	− 0.156***	1		
	Spearman Rho	0.071	0.079*	0.214***	0.062	0.037	− 0.163***	1		
SalesGrowth	Pearson	0.023	− 0.026	− 0.051	0.059	− 0.034	0.034	− 0.015	1	
	Spearman Rho	0.134***	0.007	− 0.060	0.206***	− 0.140***	0.035	0.021	1	
Europe	Pearson	0.019	0.355***	0.300***	− 0.024	0.282***	0.000	0.144***	− 0.056	1
	Spearman Rho	− 0.007	0.355***	0.292***	− 0.166***	0.309***	0.081*	0.144***	− 0.093**	1

500 firm-year observations. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively

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