Insurers' Carbon Underwriting Policies

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Abstract

We study the design, determinants, implementation, and real effects of carbon underwriting policies by large insurers. Adoption is more common among insurers from countries with stronger climate policies and less so among specialty and unlisted firms, with coal preceding oil and gas policies. Linking U.S. coal mines to insurers, we show that policy-adopting insurers reduce mine coverage, but implementation is incomplete and heterogeneous. Affected mines are likely to be abandoned and constrained, particularly when access to alternative insurance is limited. Our results are consistent with a simple insurance-supply model augmented with heterogeneous non-actuarial costs faced by insurers.

Keywords: Insurance underwriting, carbon emissions, climate change, insurance companies, coal mining

JEL Classifications: G22, Q54, L71, L51, D22

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"*[T]he insurance sector has a key role to play. [...] We need net zero commitments to cover your underwriting portfolios, and this should include the underwriting of coal—and all fossil fuels.*"

– António Guterres, UN Secretary-General at the Insurance Development Forum 2021

1 Introduction

In recent years, many insurers have adopted "carbon underwriting policies," public commitments that restrict coverage for carbon-intensive sectors such as coal, oil, and gas. Yet it remains unclear whether these commitments are more than symbolic, that is, whether insurers follow through in their underwriting practices and whether this translates into real effects on carbon-intensive activity. Insurers may adopt carbon underwriting policies when non-actuarial costs driven by stakeholder pressure and reputational concerns are sufficiently strong to affect underwriting decisions beyond considerations of actuarial risk.[1] If implemented and binding, these commitments can constrain firm behavior because insurance is often legally required for carbon-intensive projects. However, if non-actuarial costs vary across insurers, firms may be able to substitute toward insurers facing weaker stakeholder pressure, thereby limiting the real effects of adopting underwriting policies. In this paper, we provide the first systematic analysis of insurers' carbon underwriting policies, examining their design, determinants, implementation, and real effects. Our analysis uncovers a novel mechanism through which the financial sector influences firm behavior, rationalized by an insurance-supply model featuring heterogeneous non-actuarial costs.

An empirical analysis of carbon underwriting policies and their effects faces three major challenges, which may explain why systematic evidence remains scarce. First, carbon underwriting policies are a recent phenomenon and lack a standardized format, making a systematic assessment difficult. Second, commercial insurance contracts are not publicly disclosed, complicating the evaluation of whether carbon underwriting restrictions are implemented in line with public commitments. Third, comprehensive data on insured projects and their operations are necessary to assess the real effects of carbon underwriting policies, but such data are difficult to obtain.

[1] As non-actuarial costs, we consider factors that enter the decision problem of an insurer *on top of* actuarial factors related to risk-based pricing and expected losses (see Koijen and Yogo, 2023a). These costs can arise, for example, in response to pressure from retail customers, investors, or the broader public. Though non-actuarial costs do not operate through the insured risk itself, they may nonetheless generate financial consequences for an insurer.

This study exploits a setting that allows us to make significant progress on each of these three challenges. We link insurers' carbon underwriting policies to insured carbon-intensive projects and their operational outcomes, enabling an analysis of policy design, determinants, implementation, and real effects. To address the lack of standardization in carbon underwriting policies, the first challenge, we rely on scorecards from Insure Our Future (IOF), a coalition of NGOs. These scorecards provide consistent and comparable measures of the presence, scope, and stringency of carbon underwriting policies across the world's major Property & Casualty (P&C) insurers.[2] To overcome the opacity of insurance contracting, the second challenge, we filed Freedom of Information Act (FOIA) requests to obtain insurance certificates for coal mines in the United States from the relevant state-level regulators. These certificates reveal the identity of underwriting insurers, allowing us to test whether insurers' underwriting practices align with public commitments. To examine real effects, the final challenge, we match insurers' underwriting decisions to granular information on U.S. coal mines from the Mine Safety and Health Administration (MSHA). This allows us to study whether carbon underwriting policies affect mine-level production, employment, and suspension of operations.

We present three main findings. First, we trace the evolution of underwriting policies for coal as well as oil & gas projects. Carbon underwriting policies have become more common and stringent since 2017. Early adopters focused primarily on restricting coal underwriting, while restrictions on oil & gas projects typically followed a few years later. Both types of policies remain highly heterogeneous across insurers and are often vague or contain exemptions (e.g., some insurers apply them only to new, not existing projects). We show that the cross-insurer variation in policy adoption reflects tradeoffs related to stakeholder pressure. On the one hand, insurers headquartered in countries with stronger domestic climate policies are more likely to adopt carbon underwriting policies, and if they do, they adopt more restrictive ones. On the other hand, specialty and unlisted insurers—both of which plausibly face weaker pressure from retail clients or public-market investors—have a lower propensity toward restrictive policies. This cross-sectional variation motivates a framework in which underwriting decisions not only reflect risk-based pricing considerations but also heterogeneous non-actuarial costs arising from stakeholder pressure.

Second, we examine how insurers adjust underwriting activity for U.S. coal mines around the adoption of coal underwriting policies to evaluate whether these voluntary commitments are actually implemented. We find that coal policy adoptions are associated with a reduc-

[2] Green and Vallee (2025) use similar data on the exit policies of banks for fossil-fuel lending collected by Reclaim Finance, an NGO that is part of IOF.

tion in insurers' coverage of coal projects. On average, policy-adopting insurers reduce the number of insured coal mines by 16% (about 3.1 mines) and the volume of insured coal by 56% (about 3.3 million short tons, MMst), relative to non-adopters.

To address the concern that some of these results reflect time-varying sorting effects between insurers and mines, rather than causal effects of policy adoption, we exploit that mines typically obtain coverage by multiple insurers at a given point in time. This institutional feature allows us to compare how different insurers adjust coverage for the *same* mine around an individual insurer's policy adoption. Our empirical strategy follows the logic of Khwaja and Mian (2008): by leveraging within-mine variation across insurers, we hold constant the mine-insurer match and absorb all time-varying mine characteristics. In particular, this design controls for changes in mine riskiness, performance, or operational conditions, as well as for any contemporaneous shocks affecting the mine, including the adoption of lending restrictions by banks. Comparing the six quarters before and after policy adoption, the probability of an inactive mine-insurer relationship increases by 12.8 percentage points (pp), which corresponds to a 22% increase relative to the unconditional probability of 57%. Dynamic event-study estimates show no significant pre-trends and a sharp increase in inactivity of 8.4 pp in the first quarter after policy adoption. This effect rises to 18.3 pp by the fourth quarter, coinciding with the standard one-year duration of insurance policies. These results support an interpretation in which policy adoption causally affects underwriting decisions and reduces insurers' willingness to maintain coverage for coal mines. They also suggest that at least some insurers begin implementing their policies upon adoption.

We also examine cross-sectional heterogeneity in implementation driven by variation in insurers' non-actuarial costs. Effects are stronger for insurers with more stringent coal policies, consistent with implementation intensity increasing with policy strength. Across insurance lines, insurers are less likely to discontinue relationships involving worker safety and compensation coverage than more coal-exposed lines such as commercial general liability, suggesting that they preserve business relationships while reducing reputational risks associated with core mining activities.

Third, we analyze whether the adoption of coal underwriting policies affects the real operations of U.S. coal mines, which are legally required to have insurance coverage. Initial results show that non-renewal by at least one insurer—regardless of cause—is followed by a higher likelihood of mine abandonment, as well as declines in output and employment. To isolate the effect of policy adoptions, we examine whether mines insured at the beginning of our sample period by at least one insurer that subsequently adopted a coal policy are more likely to be abandoned following the first coal policy adoption by any of their insurers. Estimating dynamic effects, we find that mine abandonment emerges gradually, becoming statistically significant in the second post-adoption quarter and reaching 3.2 pp in the fourth to sixth quarters. Static comparisons yield a similar increase in abandonment likelihood of 3.6 pp. These effects are sizeable: they imply a 33% increase in the likelihood of abandonment and are particularly consequential because mine abandonment is rarely reversed. Among mines that remain operational, employment declines by about 15%. Effects on production are smaller and less precisely estimated.[3] Overall, the results indicate that policy-induced reductions in insurance coverage constrain coal mining activity.

We complement this analysis with a shift-share (Bartik) design. Rather than focusing on the first policy adoption, this approach exploits the staggered adoption of underwriting policies by additional insurers, which, for a given mine, generates variation in exposure over time. Estimated effects are similar: more exposure to coal policies increases the likelihood of mine abandonment (though estimates are somewhat less precise) and, conditional on a mine remaining operational, leads to declines in production and employment.

We also examine cross-sectional heterogeneity in the costs of insurance non-renewal faced by mines. Abandonment does not systematically vary with mine productivity or size, suggesting that opportunity costs play a limited role in how coal policy adoptions affect mine operations. In contrast, outcomes vary with the structure of insurer relationships: mines that are more dependent on a single insurer are more likely to be abandoned, whereas those with access to a broader set of alternative providers are less likely to be affected. These findings indicate that insurer dependency amplifies, and insurer substitutability mitigates, the impact of coal policies on mine operations. This highlights that individual insurer action can influence firm behavior, but the overall effectiveness depends on the availability of substitutes.

Finally, we examine changes in insurer-level outcomes around the adoption of coal policies. We find that the total gross written premiums of insurers remain unchanged after policy adoptions, reflecting either that coal-related underwriting revenues are relatively modest for the average insurer or that insurers find ways to replace lost revenue. Both annual return on assets and market-adjusted stock returns (over the two-day window surrounding adoption announcements) decline by about 0.5 pp, though these effects are not statistically significant. Interestingly, however, the number of yearly environmental incidents, as measured by RepRisk, decreases slightly, suggesting that underwriting policies come with reputational

[3] The estimates for employment show some anticipation effects. Mines may have anticipated policy adoption with some probability, leading to pre-treatment adjustments, particularly in employment given labor adjustment costs. These anticipation effects are attenuated when restricting to long-lasting insurer relationships, which likely represent more meaningful exposure to underwriting policies.

benefits for insurers. Overall, while informative, these tests do not provide conclusive evidence of insurer-level consequences, given the small sample and the fact that insurer-level outcomes reflect many activities beyond coal underwriting.

Our empirical analysis is guided by a simple insurance-supply model with non-actuarial costs in the spirit of Koijen and Yogo (2023a). In the standard framework that our model is built upon, insurers set premiums to cover expected losses, regulatory reserves, the marginal cost of capital, and other standard pricing components such as markups. We augment this framework with non-actuarial costs of coal underwriting, motivated by our evidence that reputational costs in the form of stakeholder pressure are correlated with policy adoption and stringency. In the model, insurers face two non-actuarial costs that operate on different margins of the underwriting decision. First, insurers face a fixed penalty associated with maintaining coal exposure once an underwriting policy is in place, capturing reputational losses from violating stated commitments. Second, insurers incur an additional marginal cost that captures stakeholder pressure and scales with exposure to coal underwriting. Together, these two costs allow the model to rationalize both complete withdrawal from coal underwriting and selective retrenchment: when the fixed non-actuarial cost is sufficiently large relative to the profits from coal underwriting net of risk-based costs, insurers optimally engage in abrupt non-renewals or full relationship terminations. By contrast, when the fixed cost is not prohibitive and marginal non-actuarial costs dominate the underwriting decision, insurers reduce exposure selectively by either scaling back coverage limits or exiting only the most carbon-intensive insurance lines. Finally, because some mines rely heavily on a single insurer and insurance is a non-substitutable input, withdrawal by stringent insurers can push mines below required coverage thresholds and trigger abandonment. The model therefore links policy adoption to contract-level implementation and mine outcomes within a unified framework, clarifying when insurers exit entirely, scale back selectively, and affect mine operations.

Our paper provides the first systematic evidence on insurers' carbon underwriting policies and their impact. Our results show that while such policies have become more prevalent and are implemented on average, implementation remains incomplete and heterogeneous and is partly driven by non-actuarial cost motives. Insurance non-renewals and coal policy adoptions are followed by reductions in operating activity at insured projects, suggesting that insurers can influence decarbonization through underwriting restrictions. More broadly, our findings highlight insurance as a parallel form of financial intermediation with its own transmission mechanisms to the real economy, distinct from lending and capital market channels. By documenting how underwriting decisions translate into real effects, we expand the understanding of how different financial intermediaries shape the management and allocation of climate-related risks. This interpretation is supported by anecdotal reports of mine operators caught off guard by non-renewals from insurers that had adopted carbon underwriting policies, as well as by regulatory filings in which mining companies cite the potential loss of insurance due to climate-related underwriting restrictions as a material threat to continued operations (e.g., CONSOL Energy Inc., 2020; Arch Resources Inc., 2021; NACCO Industries, Inc, 2022; Alliance Resource Partners, 2023). Although our analysis centers on coal mining, the mechanisms we document may extend to other carbon-intensive sectors, as underwriting policies for oil & gas projects exhibit similar adoption patterns and determinants. At a broader level, the effectiveness of such policies ultimately depends on the availability of substitutes, which limit the reach of individual actions. However, assessing these effects more systematically requires greater transparency on underwriting practices and insured projects, particularly because the consequences of such policies are difficult to observe at the insurer level.

We contribute to two streams of literature. Our first contribution is to the growing body of research on how the financial sector manages or addresses climate-related risks. Prior work has primarily examined providers of capital, including banks (e.g., Flammer, 2021; Kacperczyk and Peydró, 2022; Haushalter et al., 2023; Ivanov et al., 2024; Sastry et al., 2024b; Berg et al., 2025; Giannetti et al., 2025; Green and Vallee, 2025; Morse and Sastry, 2025), shareholders (e.g., Dimson et al., 2015; Krueger et al., 2020; He et al., 2023), and investor alliances (e.g., Gasparini and Tufano, 2025). Recent work shows that climate concerns can affect firms through a cost-of-capital channel, thereby incentivizing green investment (Gormsen et al., 2025). Related theoretical work characterizes when socially responsible capital can generate real effects by trading off financial returns against reductions in social costs (Oehmke and Opp, 2025). Scholars such as Acharya et al. (2023) have called for greater attention to the role of insurance companies, and a nascent body of research examines insurers' exposure to and pricing of climate risks (e.g., Ge, 2022; Jung et al., 2024; Sastry et al., 2024a; Boomhower et al., 2025; Ge et al., 2025; Kim et al., 2025; Ge et al., 2026; Oh et al., 2026). We provide the first evidence on how insurers affect the management of climate risks through underwriting restrictions on carbon-intensive projects. This mechanism differs fundamentally from the channels studied for capital providers. Whereas capital-market channels affect firms through financing conditions or investor mandates, underwriting restrictions operate at the extensive margin by withdrawing coverage that is often a legal prerequisite for continued operation. As a result, insurance can function as a non-substitutable input even for projects that remain NPV-positive.

Second, we contribute to the literature on the real effects of insurance. Prior work shows that insurance affects economic behavior primarily through risk-based pricing and coverage terms, with documented effects on household decisions such as housing market participation, post-disaster rebuilding, and precautionary investment (e.g., Meyer, 1990; Cohen and Dehejia, 2004; French and Jones, 2011; Karlan et al., 2014; Cai, 2016). Related work shows that insurers influence firms' environmental or operational risks primarily through responses to direct, near-term hazards (e.g., Yin et al., 2011) or by mitigating judgment-proof problems (e.g., Shavell, 1982, 2000, 2005; Boomhower, 2019). Legal scholars have debated the extent to which insurers can function as a form of private regulation (e.g., Ben-Sahar and Logue, 2012; Talesh, 2016; Rappaport, 2016; Abraham and Schwarcz, 2022), but systematic empirical evidence remains scarce. We provide, to our knowledge, the first link between insurers, identifiable corporate policyholders, and their operational outcomes, enabling an analysis of how insurance affects firm behavior. We establish that insurance non-renewals, both in general and following the adoption of underwriting policies, are associated with significant real effects on corporate operations. Unlike prior settings in which insurers regulate risks borne by policyholders themselves, carbon underwriting policies—shaped by non-actuarial considerations such as stakeholder pressure—target risks borne by society, revealing a novel channel through which underwriting decisions influence firm behavior and economic activity.

2 Design and determinants of carbon underwriting policies

2.1 Data and measurement

We use data on the underwriting policies of carbon-intensive projects by the world's leading insurance groups in the Property and Casualty (P&C) business from 2017 to 2023. The data are drawn from annual scorecards published by IOF, a global coalition of NGOs, and provide standardized, comparable measures of insurers' coal and oil & gas policies based on public disclosures and survey responses. During our sample period, IOF evaluated between 24 and 30 large insurance groups that represent leading underwriters of carbon-intensive activities.[4]

From these scorecards, we construct two sets of variables for each insurer-year. First, indicator variables for the presence of a coal or oil & gas policy, respectively. Second, stringency scores for coal or oil & gas policies range from 0 to 10, with higher values indi-

[4] According to IOF, the insurers covered by the scorecard are identified based on a market analysis of key providers of insurance coverage for carbon-intensive activities. IOF (2023) reports that global gross direct premiums from insuring fossil-fuel activities amounted to approximately $21 billion in 2022, based on analyses by Insuramore, a consultancy. The top 10 insurers account for up to 50% of this market, indicating substantial concentration, and seven of these insurers are included in the IOF scorecards. As an additional benchmark, a 2023 S&P Global study of the top 50 global P&C insurers by premium volume includes 25 insurers in our sample (S&P Global, 2023). Insurers in the S&P list but not in our sample typically focus on business lines unrelated to carbon-intensive underwriting, while insurers in our sample but absent from the S&P study are often specialty insurers with concentrated exposure to corporate and industrial risks.

cating more restrictive policies (i.e., comprehensive and credible underwriting restrictions) and lower values reflecting non-binding or exception-laden commitments.[5] Coal stringency scores are available from 2018 onward, and oil & gas scores from 2020.

We complement the IOF data with hand-collected information on policy announcement dates from insurer websites and news articles. Although some insurers commit to gradual underwriting phase-outs, we treat the announcement dates as the relevant starting point for our analysis, as our objective is to test whether public commitments translate into changes in underwriting activity. We further add insurer-level characteristics from ORBIS and other hand-collected insurer-level information. Table OA.2 reports hand-collected variables.

2.2 Policy adoption and stringency

Carbon underwriting policies emerge gradually over our sample period and exhibit substantial cross-sectional heterogeneity. Figure 1 shows that coal policies appear first: beginning in 2017, an increasing number of insurers introduce formal restrictions on underwriting coal-related activities, and by the end of the sample period, a majority of insurers covered by IOF have adopted some form of coal policy. In contrast, oil & gas underwriting policies emerge later, from around 2020, and remain less prevalent (Figure OA.1). Adoption is staggered across insurers and years, generating variation in treatment timing that we exploit below. A comparison of Figures 2 and OA.2 shows that the average coal policy stringency increases after 2020 (with substantial dispersion persisting across insurers), while oil & gas policies remain markedly less stringent and exhibit limited convergence over time.[6]

2.3 Determinants

The substantial variation in carbon underwriting policies calls for a systematic analysis of their determinants. We therefore construct an annual insurer panel and estimate regressions of two policy-related measures—an indicator for policy adoption and a score capturing policy stringency (for both coal and oil & gas)—on a set of variables capturing stakeholder pressure and reputational concerns. To capture public pressure reflected in local climate policies, we

[5] Stringency scores are constructed by IOF along five policy dimensions (see Table OA.1 for details).

[6] Insurers also hold large investment portfolios and may respond to climate-related concerns through screening or divestment on the asset side of their balance sheets (see, e.g., Ellul et al., 2011; Koijen and Yogo, 2023b; Knox and Sørensen, 2024; Kubitza, 2026; Ge and Weisbach, 2021). However, underwriting and investment policies are imperfectly correlated. Table OA.3 reports positive but far from perfect correlations between insurers' underwriting and fossil-fuel investment policies, and Figure OA.3 shows substantial within-insurer variation in policy stringency across the asset and liability sides. This suggests that underwriting restrictions do not merely reflect ESG-related investment decisions but constitute a distinct channel. Moreover, our implementation analysis exploits within-mine variation in insurer relationships, helping to absorb coinciding mine-level shocks that could be related to insurers' investment behavior.

include the Climate Change Performance Index (CCPI) in an insurer's headquarters country. We further include whether an insurer is a member of the Net-Zero Insurance Alliance (NZIA), capturing peer pressure toward aligning underwriting portfolios with net-zero targets. To capture the absence of pressure from retail clients—who may prefer their insurers not to underwrite carbon-intensive assets because of green preferences—we include an indicator for whether an insurer is a specialty insurer focused on corporate business lines. To capture pressure from investors, we consider whether an insurer is a listed or unlisted entity. Unlisted insurers may face less pressure because their lower public visibility and lack of capital markets exposure make them less sensitive to investor scrutiny, ESG ratings, and reputational risks, relative to listed insurers. All specifications control for insurers' exposure to fossil fuel underwriting (using the share of an insurer's gross written premium from insuring fossil fuels), insurer size, an insurer's overall profitability, and time fixed effects.[7]

Table 1 presents results for coal policies. Column 1 analyzes the extensive margin—whether an insurer has a coal policy in place—over the 2017-2023 period. Two main insights related to the role of stakeholder pressure emerge. First, adoption is significantly more common among insurers headquartered in countries with stronger climate policies, while specialty insurers, who face weaker retail scrutiny, are less likely to adopt a coal policy. Second, public-market investor pressure appears to play an important role: unlisted insurers are significantly less likely to adopt coal policies. Next to these effects, insurers that are more dependent on fossil-fuel revenues are less likely to adopt coal policies. Column 2 examines the intensive margin—policy stringency conditional on adoption—over the 2018-2023 period. The determinants in these regressions are broadly consistent with those found for adoption.

In Table OA.5, we present the corresponding results for oil & gas policies, which can be studied from 2020 onward and over a smaller sample due to their later and less frequent adoption. The determinants of policy adoption and stringency are similar to those for coal. This suggests that the same institutional and strategic factors shape underwriting behavior across carbon-intensive sectors, and that the mechanisms documented in the coal mining analysis may generalize to other carbon-intensive sectors.

In sum, our evidence indicates that adoption and stringency are associated with insurer-specific non-actuarial costs, related to stakeholder pressure and reputational concerns. Motivated by this evidence, Online Appendix A presents an insurance-supply model with non-actuarial costs that rationalizes heterogeneous policy adoption and provides a unified framework for understanding implementation and withdrawal patterns that we document below.

[7]Table OA.4 presents descriptive statistics on all variables, and definitions are provided in Table A.1.

3 U.S. coal mining insurance

3.1 Motivation

The previous section documents the rise of carbon underwriting policies across insurers. Yet it remains unclear whether these policies are meaningfully implemented and whether they have real effects on carbon-intensive projects. On the implementation side, non-actuarial costs of underwriting coal may induce some insurers to reduce coverage following policy adoption, while others continue underwriting, either because such costs are weaker for them or are outweighed by other considerations. On the consequences side, it remains unclear whether any resulting coverage reductions are sufficiently large and whether substitution across insurers is sufficiently limited to affect the operations of carbon-intensive projects.

We address these questions in the context of coal mining in the United States, analyzing the real effects of globally adopted carbon underwriting policies within a single-country setting, which provides several benefits. First, relative to oil & gas, coal policies emerged several years earlier, allowing for a longer sample period. Second, coal production continues to grow globally (Enerdata, 2025) and represents a critical upstream activity for coal combustion, the single largest source of human-induced climate change (IEA, 2021; ClientEarth, 2022), yet it is underexplored by empirical research (Kellogg and Reguant, 2021). Third, while coal mining in North America has been in secular decline, the United States remains the world's fourth-largest coal producer, and insurance coverage is a legal prerequisite for mine operations. Fourth, the United States provides exceptionally detailed mine-level information, including insurance relationships and quarterly operating characteristics, enabling a direct link between policy adoptions and project-level outcomes.

3.2 Data

Data on U.S. coal mines come from the MSHA. Under federal regulation, the MSHA collects data on coal production, employment, operating status, and other operational metrics at the mine-quarter level.[8] We construct a quarterly panel dataset of all coal mines that report at least one quarter of non-zero coal production between 2014Q1 and 2024Q2. By starting in 2014, we include data prior to the introduction of coal underwriting policies to compare mine behavior before and after policy adoptions.

Coal mine operators in the United States are required to maintain liability insurance as a condition for obtaining or renewing their operating permits. This mandate is enforced by

[8] We use data obtained from MSHA's Mine Data Retrieval System. For further information on these data, see Charles et al. (2022), Gilje and Wittry (2022), Qiu et al. (2025), and Chen and Wittry (2025).

state mine regulators under the Surface Mining Control and Reclamation Act of 1977 and Title 30 of the Code of Federal Regulations. Operators must also meet minimum coverage standards set by relevant state agencies, typically covering workplace injuries, third-party claims, and environmental risks. Because proof of adequate coverage is a legal prerequisite for continued operation, insurers hold substantial influence over coal mines: by choosing whether to issue or renew policies, they effectively determine whether a mine is allowed to operate.

As part of the permitting process, state regulators maintain detailed records of mine-level insurance coverage. To access these data, we filed FOIA requests with the relevant agencies, requesting Certificates of Liability Insurance for all mines in the MSHA database since 2014.[9] These mines span 25 states, of which eight states supplied comprehensive certificate data in the form of standardized ACORD 25 filings.[10] The final mine sample is concentrated in major coal-producing regions (Preonas, 2024), including West Virginia (69%) and Virginia (16%), with the remaining mines located in Illinois (6%), Wyoming (4%), Utah (2%), Colorado (2%), Montana (1%), and North Dakota (1%). Overall, the sample accounts for 78% of U.S. coal production from 2014Q1 to 2024Q2.

Figure OA.4 shows the ACORD 25 insurance certificate for the Black Butte Coal Mine in Wyoming. Each certificate comprises three main sections. The top section lists the insurance broker ("producer"), the insured entity ("insured"), and the insurers ("insurer(s) affording coverage").[11] The middle section details policy-level information, including the start and end dates of coverage. Insurance policies are categorized into one of four insurance lines: commercial general liability, automobile liability, workers' compensation and employer's liability, and umbrella/excess liability (which includes other insurance lines such as pollution liability). The bottom section identifies the regulatory agency responsible for oversight and compliance.

Our dataset comprises 9,745 insurance policies across 456 sampled mines. We define a policy as a unique insurer-insurance line combination listed on a certificate. A mine may

[9] As some states do not accept FOIA requests from non-U.S. citizens/residents or out-of-state requesters, two requesters and FOIA advocacy groups assisted us in obtaining some of the records. We verified that the obtained data can be used by non-U.S. citizens/residents.

[10] Maryland and New Mexico are not included in our sample because they only provided the most recent certificates and no historical records, despite follow-up efforts. From Alaska, Arizona, Arkansas, Kansas, Louisiana, Missouri, Mississippi, Oklahoma, and Tennessee—states that each have five or fewer mines—we did not receive a response to the FOIA requests. We exclude Ohio, Kentucky, and Texas because their agencies do not use standardized certificate forms, making their data difficult to compare with that of other states. Indiana did not provide any information. Our requests in Alabama and Pennsylvania are still pending.

[11] Mining companies may opt for self-insurance, also known as captive insurance. We identify such cases either when the top section of the certificate explicitly mentions a captive insurance company or when it explicitly states that the mine is self-insured. Fewer than 20 certificates in our sample indicate self-insurance. This low number may reflect substantial costs and regulatory requirements associated with establishing and maintaining captive insurers.

hold multiple policies from different insurers, even for the same insurance line. Around 37% of policies cover commercial general liability, 30% umbrella/excess liability, 17% automobile liability, and 16% workers' compensation and employer's liability. Roughly 90% of all policies have a duration of one year.[12]

3.3 Linking mines to insurer-level policies

We link mine-level data from the MSHA with insurer-level coal underwriting policies using the Certificates of Liability Insurance to create a mine-quarter-insurance policy panel. This task requires mapping the insurers listed on the certificates to their corresponding insurance groups.[13] Although the certificates specify start and end dates for each policy, the MSHA data are at the mine-quarter level. To merge these data, we assume a mine is covered by a given policy in a quarter if the policy covers the start date of that quarter.[14]

The final dataset covers 456 coal mines insured by 46 insurance groups between 2014Q1 and 2024Q2. Among these insurers, 15 appear in the IOF scorecards, with 11 introducing a coal policy during the sample period. We assume that the 31 insurance groups not covered by IOF do not adopt such policies, an assumption supported by extensive news searches and discussions with IOF. Hence, 35 insurance groups do not have a coal policy (four covered by IOF and 31 uncovered). While this sample omits some insurers from the IOF scorecards, either because they insure coal mines outside the U.S. or implement underwriting restrictions differently in other markets, it reliably captures the primary actors in U.S. coal mine insurance.

3.4 Summary statistics

Table 2 reports descriptive statistics for the sample at different levels of aggregation. The raw dataset is at the mine-quarter-policy level, identifying for a given mine-quarter which insurance policies are active and which insurance group provides coverage.

[12] We do not observe policy-level premium amounts, as the certificates do not report pricing information. Therefore, our analysis focuses on policy non-renewals. Although insurers could, in principle, adjust premiums, doing so may require modifications to filed rating plans and must remain actuarially defensible under review by state insurance departments. By contrast, non-renewals represent a more direct margin of adjustment.

[13] We perform this mapping using the 5-digit NAIC company codes provided on the certificates, cross-referenced with group affiliations from NAIC's semiannual publication *Listing of Companies* as of June 2017, before the announcement of any carbon policies. We evaluate the possibility of ownership changes after 2017 (e.g., through mergers and acquisitions) and find these to be rare. In fact, only one coal mine-insuring subsidiary changes group affiliation after this date. Policies that cannot be matched to an insurance group are excluded, though such cases are rare (fewer than 2% of all policies).

[14] This rule effectively lags mine-level outcomes by up to one quarter relative to changes in insurance coverage, since coverage is assigned based on whether the quarter's start date falls within the coverage period.

Panel A reports statistics at the mine-quarter-insurance level, enabling us to track mine-insurer relationships over time. For each mine, we include all observed mine–insurer relationships and populate inactive quarters. Specifically, for each insurer that appears on a mine's certificate once, we retain that mine–insurer pair for all quarters with available certificate data for the mine, coding periods without coverage as inactive. The average relationship lasts 14.2 quarters, or roughly 3.5 years. In 47% of all observations, the insurer has a coal policy in place and in 57% of observations, the relationship is inactive, that is, the mine is not insured by the respective insurer.

Panel B provides statistics at the insurer-quarter level, which we use to study insurer-level changes around policy adoptions. On average, an insurer underwrites about 20 coal mines, corresponding to 6 MMst of coal production per quarter. A coal policy is in place in 28% of insurer-quarter observations.

Finally, Panel C presents statistics at the mine-quarter level, which is used to analyze operational outcomes of coal mines. In 11% of mine-quarters, a mine is classified as abandoned. In our data, abandonment is rarely reversed; thus, it is effectively an absorbing state. On average, a mine produces 0.35 MMst of coal and employs 71 workers per quarter.[15] In 7% of mine-quarters an insurance contract is not renewed. Around four insurers provide coverage in a given quarter.

4 Implementation of carbon underwriting policies

4.1 Trends in insurance coverage by coal policy status

To provide initial evidence on changes in insurance coverage following the adoption of coal underwriting policies, Figure OA.5 plots the number of coal mines insured by insurers that introduced a coal policy at some point during the sample period (Panel A), and by those that never did (Panel B). In Panel A, the number of insured mines remains relatively stable at around 200. However, there is considerable heterogeneity within this group. AIG, which dominates the market in the early sample years alongside Chubb, insures fewer mines over time, while Zurich emerges as the main insurer in later years. In contrast, Panel B shows that among insurers that never adopt a coal policy, the number of insured mines increases steadily over time, from about 100 at the beginning of the sample period to nearly 300 by the end. Houston and BrickStreet are the primary underwriters in this group. However,

[15] The largest mine in our sample, the North Antelope Rochelle Mine, employs more than 1,300 workers. Production and employment are typically zero when a mine is abandoned. However, active mines can also report zero production and employment in some quarters.

there is also heterogeneity within non-adopters. For example, Berkshire Hathaway reduced its coverage considerably. The contrasting trends across the two panels suggest that insurers adopting coal policies reduce their exposure to coal mining, while those without such policies tend to expand their underwriting.

Figure OA.6 reports analogous patterns using the volume of insured coal production. Among insurers with coal policies, reductions in the number of insured mines do not always translate into proportional declines in insured coal volume, suggesting that coverage adjustments are concentrated among smaller mines. This further underscores the heterogeneity in how underwriting policies are implemented, which we analyze in detail below.

4.2 Insurer-level effects of coal policy adoption

To formally test whether coal underwriting activity declines following the adoption of coal policies, we estimate the following OLS regression at the insurer-quarter level:

$$\textit{Coal insurance}_{i,t} = \beta \times \textit{Post coal policy}_{i,t} + \alpha_i + \alpha_t + \epsilon_{i,t}, \tag{1}$$

where i indexes an insurer and t a quarter. *Coal insurance* denotes the log of either the number of insured coal mines (*# Coal mines insured*) or the volume of produced coal at insured mines (*Coal volume insured*). *Post coal policy* equals one for insurer-quarters after a coal underwriting policy is introduced, and zero otherwise. α_i and α_t are insurer and time fixed effects, respectively. We use robust standard errors. β captures the change in coal underwriting activity among insurers that adopt a coal policy, relative to those that do not, at the same point in time. If insurers adjust their underwriting activity in line with public commitments, we expect β to be negative and statistically significant.

Table 3 reports estimates of Eq. 1. In Column 1 for *# Coal mines insured*, the β estimate is negative and statistically significant, indicating that insurers, on average, reduce the number of insured coal mines by about 16% ($\approx e^{-0.172}-1$, or 3.1 mines) following policy adoption. In Column 2 for *Coal volume insured*, the estimate continues to be negative and significant, implying a reduction in the volume of insured coal by about 56% ($\approx e^{-0.824}-1$, or 3.3 MMst) after policy adoption. Hence, coal policies substantially reduce coal underwriting activity.

A limitation of this analysis is that we observe whether insurance contracts are renewed, but not the reason why insurance coverage ends. In particular, we cannot distinguish whether coverage ends due to insurer-level factors, such as adoption of coal underwriting policies, or due to mine-level factors such as operational or financial difficulties. To address this limitation to some extent, Columns 3 and 4 restrict the sample to mines that remain operationally active throughout the sample period. The continued negative and significant β estimates suggest that results are not driven by changes in mine operating status.

4.3 Mine-insurer relationship effects of coal policy adoption

The results in the previous section do not allow for a causal interpretation. First, they do not account for the endogenous matching of coal mines to insurers, and we cannot rule out that insurers adopt coal policies because of the specific mines they insure. Second, they do not control for time-varying mine characteristics that could influence insurers' renewal decisions, for example, deteriorating mine performance or rising operational risk, or adverse shocks to the mine's financial conditions, including tighter bank credit. To address these concerns, we exploit that mines obtain coverage by multiple insurers at a given point in time, allowing us to compare how different insurers adjust coverage for the same mine around an insurer's policy adoption. This approach, in the spirit of Khwaja and Mian (2008), holds constant the mine-insurer match and time-varying mine characteristics.

We implement this identification strategy using a stacked difference-in-differences (DiD) design, which addresses concerns arising from staggered treatment timing (e.g., Gormley and Matsa, 2011; Callaway and Sant'Anna, 2021; Goodman-Bacon, 2021; Sun and Abraham, 2021; Baker et al., 2022). A stack is defined as one policy-adopting insurer and all coal mines it insures. For each mine-insurer pair in that stack, we construct a balanced panel of 13 quarterly observations, six before and six after the policy adoption quarter. These mine-insurer pairs constitute the treated observations in the stack. Control observations are all other mine-insurer pairs involving the same mines but insurers that never adopt a coal policy, thereby avoiding anticipatory effects. Intuitively, each stack tracks how mine-insurer relationships evolve around the adoption of a policy by one insurer, comparing changes in coverage between the adopting insurer and insurers that never adopt a policy within the same mine and quarter. We repeat this procedure for each of the 11 policy-adopting insurers and stack the samples to estimate the average effect of coal policies on the likelihood of observing inactive insurer-mine relationships. Specifically, we estimate the following dynamic DiD regression with OLS:

$$\begin{aligned} Inactive\ insurance_{s,m,i,t} = \sum_{t=-6}^{t=6} \beta_t \times Coal\ policy_i \times Event\ quarter_{s,t} + \\ \alpha_{s,m,i} + \alpha_{s,m,t} + \epsilon_{s,m,i,t}, \end{aligned} \tag{2}$$

where s indexes a stack, m indexes a mine, i an insurer, and t a quarter. *Inactive insurance* equals one if an insurer does not insure a mine in a given quarter, and zero if it does. *Coal policy* equals one for insurer-mine pairs involving a policy-adopting insurer, and zero otherwise. *Event quarter* are dummies indicating quarters relative to policy adoption. $\alpha_{s,m,i}$ are stack-mine-insurer fixed effects, while $\alpha_{s,m,t}$ are stack-mine-time fixed effects.[16] These fixed effects ensure that we compare the evolution of mine-insurer relationships across insurers within the same mine and quarter, thereby controlling for the match of mines to insurers, the concern that policy adoptions could be driven by specific insurer-mine relationships, and unobservable time-varying mine characteristics (e.g., changes in mine operations or the adoption of climate-related lending restrictions by banks). Standard errors are clustered at the insurer-stack level. If insurers adjust their underwriting activity in line with public commitments, we expect the β_t coefficients to be indistinguishable from zero prior to adoption and significantly positive afterwards.

Figure 3 presents the estimated quarterly coefficients from Eq. 2, relative to the omitted quarter preceding policy adoption. In the quarters leading up to adoption and in the adoption quarter, there are no significant differences in the likelihood of inactive insurance relationships, supporting the parallel trends assumption. Starting in the first post-adoption quarter, however, relationships between mines and policy-adopting insurers are significantly more likely to become inactive. This likelihood increases steadily, from 8.4 pp in the first quarter to 18.3 pp by the fourth quarter. The effect then levels off, consistent with the typical one-year duration of insurance policies, by which time most non-renewals would have taken effect. The sharp discontinuity around policy adoption provides evidence that coal policies drive changes in underwriting activity, and it suggests that at least some insurers begin to implement their policies upon introduction. This interpretation is supported by anecdotal reports that some coal mines were caught off guard by non-renewals.[17] Consistent with this evidence, the model in Online Appendix A shows that policy adoption reflects non-actuarial costs that are sufficiently high to make continued coal underwriting suboptimal, leading insurers to withdraw coverage.

To complement these dynamic estimates, we define a post-adoption indicator (*Post*) that equals one for the quarters after the introduction of a coal policy, and interact it with the *Coal policy* indicator. We then estimate the following static DiD regression with OLS:

$$Inactive\ insurance_{s,m,i,t} = \beta \times Coal\ policy_i \times Post_{s,t} + \alpha_{s,m,i} + \alpha_{s,m,t} + \epsilon_{s,m,i,t}. \quad (3)$$

Table 4 reports estimates of Eq. 3. In Column 1, the coefficient on the interaction term

[16]The fixed effects absorb the standalone effect of *Coal policy* and the *Event quarter* dummies.

[17]For example, several member companies of the Lignite Energy Council (LEC), a trade association for the coal industry, reported receiving non-renewal notices from insurers. One company was forced to scramble for alternative coverage within months (Guidehouse Inc., 2022).

indicates that relationships between a mine and a policy-adopting insurer are 12.8 pp more likely to become inactive in the six quarters following adoption, a 22% increase relative to the unconditional probability of 57%. In Column 2, among mines that remain active throughout the sample, the estimate increases to 13.7 pp. Overall, these results imply that non-renewals reflect changes in insurer behavior driven by coal policy adoptions rather than changes in mine characteristics.

4.4 Cross-sectional variation in insurers' non-actuarial costs

The preceding results show that insurers adopting a coal policy are, on average, more likely to terminate their insurance relationships with coal mines. However, the estimated effects remain well below full cancellation, motivating an analysis of how they vary with non-actuarial costs related to stakeholder pressure that affect the characteristics of the underwriting and insurance policies. First, if underwriting policy stringency reflects the intensity of insurers' non-actuarial costs, insurers with more stringent policies should be more likely to terminate insurance relationships with coal mines. To test this prediction, we augment Eq. 3 by interacting the post-adoption indicator with two measures of policy strength: (i) *First coal policy score*, the insurer's policy score at adoption,[18] and (ii) *Max coal policy score*, the highest policy score observed for an insurer during the sample period. Table 5, Columns 1 and 2, present the results. The positive and significant coefficients on the interaction terms indicate that implementation intensity increases with policy stringency. A one-standard-deviation increase in the stringency score is associated with a 2.6 to 4.2 pp higher likelihood that a mine-insurer relationship becomes inactive following policy adoption. This pattern implies that insurers with broader and more credible underwriting restrictions (policies with fewer exceptions and wider coverage across business lines and project types) are more likely to terminate coverage.

Second, if insurers' non-actuarial costs are higher for insurance lines more closely tied to coal mining activity, we should observe higher rates of discontinuation for more coal-exposed lines (commercial general liability, umbrella and excess liability, and automobile liability) than for less coal-exposed lines (workers' compensation). To test this prediction, we first replicate the stacked DiD specification at the insurance line level. The static estimates in Table 5, Column 3, and the dynamic estimates in Figure OA.7 indicate that the aggregate pattern holds across insurance lines. Next, we add interaction terms with dummies for specific insurance lines, with results reported in Table 5, Column 4. Relationships involving workers' compensation insurance are significantly less likely to become inactive than those

[18] As the first IOF scorecard, published in 2017, does not include stringency scores, we use the 2018 stringency scores for insurers that adopted a policy in 2017.

covering commercial general liability (the omitted category). While the baseline post-policy effect of coal policy adoption is positive (0.125), the triple interaction for workers' compensation is -0.135, offsetting this effect. This suggests that insurers retain coverage related to worker safety and compensation, a finding confirmed by a joint significance test.[19]

Overall, the findings show that coal policies lead to substantial reductions in insurance coverage for coal mines, especially among insurers with stronger policy commitments. The effects also vary systematically across insurance lines, suggesting that insurers selectively reduce coverage to maintain business relationships with mines while reducing reputational risks from directly insuring core mining activities. These heterogeneity patterns align with the model in Online Appendix A, which predicts that insurers with more stringent policies withdraw more aggressively, in particular from insurance lines with higher reputational exposure.

5 Real effects of carbon underwriting policies

5.1 Effects of insurance non-renewal on mine outcomes

Having established that insurers reduce the underwriting of carbon-intensive projects following the adoption of coal policies, we now examine the consequences for insured projects. As a starting point, we test whether the end of insurance coverage, regardless of whether it is driven by policy adoption or other factors, is associated with subsequent changes in mine operations. We estimate the following OLS regression at the mine-quarter level:

$$\textit{Coal mine outcome}_{m,t} = \sum_{k=1}^{k=4} \beta_k \times \textit{Non-renewed insurance}_{m,t-k} + \alpha_m + \alpha_t + \epsilon_{m,t}, \qquad (4)$$

where m indexes a mine and t a quarter. *Coal mine outcome* is one of three measures: (i) a dummy for whether a mine is abandoned (*Abandoned*), (ii) the volume of coal produced (*Production*), or (iii) the number of employees (*# Employees*).[20] *Non-renewed insurance* equals one if, in quarter $t-k$, with $k \in [1, 4]$, at least one of the mine's insurers did not renew coverage, and zero if all insurers maintain coverage. α_m and α_t are mine and time fixed effects, respectively. Standard errors are clustered at the mine level. The β_k coefficients capture how

[19]These results are consistent with anecdotal evidence suggesting that insurers are willing to maintain coverage for social or safety reasons even when restricting others. In announcing its carbon underwriting policy, SCOR explicitly carved out exceptions for coverage related to worker and community protection: "*SCOR will not issue insurance or facultative reinsurance that would specifically encourage new greenfield thermal coal mines or stand-alone lignite mines or plants. The only exception to this rule would be the implementation of cover for the benefit of the local community or workers.*" (SCOR, 2017). Similarly, Zurich's latest coal underwriting policy explicitly exempts "*workers' compensation, other employee protections, or considerations, which have a positive impact on human health and the environment.*" (Zurich, 2025).

[20]We do not observe mine-level profitability, which would offer a direct measure of economic performance.

mine outcomes change in each of the four quarters following non-renewal, relative to other mines in the same quarters. If non-renewals negatively affect operations, we expect positive coefficients on abandonment and negative coefficients on production and employment.

Table 6 reports estimates of Eq. 4. Column 1 shows that the likelihood of abandoning a mine increases significantly by up to 1.4 pp over the four quarters after non-renewal. The effects in the first three quarters are also positive, but are estimated more noisily. Columns 2 and 3 reveal that active mines reduce output and employment after coverage ends. Coal production declines by 4 to 11% over the four-quarter window, although only the second-quarter estimate is statistically significant. Employment falls by 5 to 11%, with all four estimates being statistically significant. These results suggest that non-renewals—regardless of the reason—are associated with a higher likelihood of mine abandonment and reduced operational activity. Combined with our findings that insurer-mine relationships are more likely to end following policy adoption, this provides initial evidence that underwriting policies can translate into meaningful real effects.

5.2 Effects of coal underwriting policies on mine outcomes

While the preceding results show that insurance non-renewal is associated with changes in coal mine operations, they do not consider the underlying drivers of non-renewal. To examine the implications of coal policy adoptions, we study outcomes of mines that are "coal policy exposed," that is, mines insured at the beginning of the sample period (before any coal policies were introduced) by at least one insurer that subsequently adopted a coal policy. This approach ensures that treatment is predetermined relative to later mine outcomes and controls for the selection of mines into the underwriting portfolios of policy-adopting insurers. For each group of insurers adopting a coal policy in the same quarter, we construct a stack comprising all their mines at the point of the first coal policy adoption by any of their insurers, observed over a symmetric 13-quarter window around policy adoption. Control observations are drawn from mines that, at the beginning of the sample period, are insured exclusively by insurers that never adopted a coal policy. We then estimate the following dynamic DiD regression with OLS:

$$Coal\ mine\ outcome_{s,m,t} = \sum_{t=-6}^{t=6} \beta_t \times Coal\ policy\ exposed_{s,m} \times Event\ quarter_{s,t} + \alpha_{s,m} + \alpha_{s,t} + \epsilon_{s,m,t}, \tag{5}$$

where s indexes a stack, m a mine, and t a quarter. *Coal mine outcome* is one of the three outcomes used above (*Abandoned*, *Production*, *# Employees*). *Coal policy exposed* equals one if a mine is insured during 2014 and 2016 by at least one insurer that subsequently adopted a coal policy, taking effect at the first adoption by any of its insurers, and zero otherwise. *Event quarter* are dummies for quarters relative to the earliest quarter in which the insurer adopts a coal underwriting policy. $\alpha_{s,m}$ are stack-mine fixed effects, and $\alpha_{s,t}$ are stack-time fixed effects, ensuring that we study within-mine variation and compare changes in mine outcomes with non-exposed mines at the same point in time.[21] These fixed effects account for common trends in the secular decline of U.S. coal production and employment, as well as other time-varying factors that jointly affect all mines. Standard errors are clustered at the mine-stack level. If coal policies constrain operations, the β_t coefficients should be zero prior to adoption and positive (for abandonment) or negative (for production and employment) thereafter.

Figure 4 plots the dynamic estimates of Eq. 5, relative to the quarter before adoption. Panel A documents the absence of pre-trends for abandonment, alongside a notable increase in abandonment beginning in the second post-policy quarter, reaching 3.2 pp in the fourth quarter and remaining elevated thereafter. Panel B reveals no consistent pattern for coal production. Panel C shows modest upward pre-trends in employment and a significant decline after policy adoption. The pre-treatment dynamics are consistent with forward-looking adjustment. Given labor adjustment costs in mining, anticipated underwriting restrictions may lead firms to gradually incorporate expected downsizing into employment decisions. By contrast, extraction is intertemporal: if future insurance constraints are expected to tighten, mines may have incentives to front-load production before restrictions bind. Following policy adoption, the increase in abandonment suggests that reduced insurance availability pushes some mines below the regulatory coverage threshold, inducing exit. Overall, the evidence indicates that coal policies constrain mine operations. These dynamics align with the model in Online Appendix A, where mines must satisfy a regulatory minimum coverage threshold, so insurer withdrawal can directly induce mine exit and reductions in activity once total available coverage falls below the required level.

To complement this dynamic specification, we run a static DiD regression with OLS in which we replace the event-time indicators with a single post-treatment indicator (*Post*):

$$Coal\ mine\ outcome_{s,m,t} = \beta \times Coal\ policy\ exposed_{s,m} \times Post_{s,t} + \alpha_{s,m} + \alpha_{s,t} + \epsilon_{s,m,t}. \quad (6)$$

Table 7 reports the results of Eq. 6. Column 1 shows that mines exposed to coal policies are 3.6 pp more likely to be abandoned (33% relative to the sample mean). Columns 2 and 3 examine the intensive margin, restricting the sample to continuously active mines. The estimates point to post-adoption declines in production by about 8% (or 0.024 MMst) and

[21] The fixed effects absorb the standalone effect of *Coal policy* and the *Event quarter* dummies.

in employment by 15% (or 10 employees). The production estimates are not statistically significant, whereas the abandonment and employment effects are. These results suggest that coal policy adoptions are linked to reductions in mine viability.[22]

So far, we have studied the first adoption of a coal policy (the extensive margin). We now analyze repeated treatments of mines, exploiting cases where additional insurers adopt policies over time (the intensive margin). To this end, we implement a shift-share (Bartik) design, following Goldsmith-Pinkham et al. (2020) and Green and Vallee (2025). We define the Bartik-style exposure of mine m in quarter t as $Share\ coal\ policy\ exposed_{m,t} = \sum_i w_{m,i} \times Post\ coal\ policy_{i,t}$. Intuitively, this measure captures mine m's share of insurers ($w_{m,i}$) that provided coverage during 2014 and 2016 and have adopted a coal policy by quarter t (i.e., insurers for which $Post\ coal\ policy_{i,t} = 1$). A mine's exposure thus increases with each additional policy-adopting insurer, generating shift-share variation in treatment intensity across mines and over time. This analysis relies on two additional assumptions. First, due to the lack of information on the relative importance of insurers for a given mine, we assume that all insurers contribute equally to a mine's exposure (assigning equal weights $w_{m,i}$). Second, we limit the set of mines and insurers to insurer-mine relationships lasting at least eight quarters in the 2014-2016 period, ensuring that exposure reflects sustained ties.[23] We implement this identification strategy by regressing each of the three quarterly mine outcomes on the shift-share instrument as well as time and mine fixed effects, using the mine-quarter panel described in Panel C of Table 2. The estimates in Table OA.6 continue to show meaningful increases in the likelihood of mine abandonment (Column 1) and, conditional on remaining operational throughout the sample period, declines in production (Column 2) and employment (Column 3). However, the coefficient for abandoned mines is not statistically significant at conventional levels. These additional results support the association between insurer policies and mine operations.

Our finding that insurance non-renewal following coal underwriting policy adoptions can constrain mine operations is consistent with anecdotal evidence. For example, coal mine operators required to file with the Securities and Exchange Commission (SEC) regularly mention challenging insurance markets for coal mines because of ESG considerations, cite

[22]Figure OA.8 reports estimates from the staggered event-study estimator of de Chaisemartin and d'Haultfœuuille (2026), which is robust to treatment-effect heterogeneity and represents another way to mitigate biases in staggered-adoption settings. The effects are similar in magnitude to our baseline and the pre-treatments are weaker for abandonment (Panel A) and employment (Panel C), but effects are estimated with lower statistical precision.

[23]The dynamic post-treatment effects become cleaner when using the refined eight-quarter relationship definition (see Figure OA.9), supporting the notion that longer-lasting insurer ties capture more meaningful exposure.

inability to obtain insurance as a risk factor, or warn that resulting non-renewal of insurance policies could adversely affect coal mine production activities and operating results (e.g., CONSOL Energy Inc., 2020; Arch Resources Inc., 2021; NACCO Industries, Inc, 2022; Alliance Resource Partners, 2023). Such frictions may manifest in employment reductions and precautionary abandonment before output is scaled back, especially when contractual obligations or stored inventories allow mines to sustain production temporarily.

5.3 Cross-sectional variation in mines' costs of insurance non-renewal

We examine cross-sectional heterogeneity in mine outcomes by augmenting Eq. 6 with triple interaction terms. This analysis focuses on mine abandonment, which provides the largest sample size (relative to production or employment outcomes) and constitutes the most drastic operational response. We consider two dimensions of heterogeneity. First, we test whether mines that are more dependent on specific insurers or have fewer alternative providers are more affected. We proxy dependency using *Relationship insurer*, which equals one if a mine has at least one insurer that provided coverage for at least eight quarters during the 2014-2016 period. Access to alternatives is measured using *Many insurers*, which equals one if a mine is covered by an above-median number of distinct insurers during the same period. Columns 1 and 2 of Table 8 show that the effect of coal policies on mine abandonment is stronger for mines that are more reliant on specific insurers, either by having a relationship insurer or by lacking alternative providers. Hence, insurer dependency amplifies, and insurer substitutability mitigates, the effects of coal policy adoptions. This pattern is consistent with the model in Online Appendix A, which highlights that real effects of insurer withdrawal depend on the availability of substitutes: when a mine relies heavily on a small set of insurers, the withdrawal of one insurer is more likely to push total coverage below the required threshold.

Second, we test whether opportunity cost considerations drive abandonment decisions. While we do not observe mine-level profitability, we can classify higher-opportunity-cost mines as those with above-median productivity (*Productive mine*, proxied by average output per working hour) or above-median size (*Large mine*, measured by total production) during the 2014-2016 period. Table 8, Column 3, indicates that more productive mines are generally less likely to be closed post-policy adoption, but this effect does not vary by exposure to coal policies. Finally, Column 4 shows no significant difference in abandonment probabilities between large and small mines, although the coefficient on the triple interaction term suggests a higher likelihood of abandonment among larger mines. Overall, mine characteristics such as productivity and size do not materially influence abandonment decisions following coal policy adoptions, whereas dependency on insurers and availability of alternative coverage do.

Taken together, the results in this section suggest that coal underwriting policies can have meaningful effects on mine operations. Non-renewal of insurance contracts, regardless of cause, is linked to a higher likelihood of mine abandonment and reductions in output and employment. Adoptions of coal policies yield similar effects, strengthening the interpretation that coal policies result in operational changes. Because abandonment is rarely reversed, these declines suggest lasting or permanent closures. The magnitude of the effects increases with exposure to policy-adopting insurers, pointing to a role for insurers' underwriting decisions in shaping coal mine activity. While abandonment decisions do not vary systematically with mine characteristics such as productivity or size, they are sensitive to the structure of insurer relationships, as the effectiveness of coal underwriting policies is shaped by the degree of insurer dependency and substitutability. When firms can easily switch providers, the influence of individual insurers is more limited, reflecting how market structure affects the effects of individual insurer actions.

5.4 Effects of coal underwriting policies on insurer outcomes

Our finding that insurers adjust underwriting behavior following the adoption of coal underwriting policies raises the question of whether such policies meaningfully affect insurer-level outcomes. For insurers, adopting coal policies entails trade-offs. On the one hand, reduced underwriting activity may lead to lower income. On the other hand, such policies may decrease non-actuarial costs and generate reputational benefits that may enhance franchise value. Assessing these trade-offs comprehensively is challenging because coal-related activities account for only a small share of insurers' overall business, our sample of adopting insurers is limited, and any effects may take time to materialize. With these caveats in mind, we examine changes in five insurer-level outcomes around adoptions of coal underwriting policies: gross written premiums as a measure of operating income (*GWP (log)*), return on assets as a measure of profitability (*ROA (%)*), abnormal stock returns around the announcement of coal policy adoptions as a forward-looking measure of shareholder wealth (*CAR[0,1]*), an insurer's solvency ratio as a measure of riskiness (*Solvency ratio*), and the number of environmental incidents to capture reputational risks (*# RepRisk incidents*).

Results are reported in Table 9. Gross written premiums, presented in Column 1, remain unchanged around the adoption of coal policies. Return on assets in Column 2 declines by about 0.5 pp, though the effect is not statistically significant. Similarly, abnormal announcement returns around adoptions are negative, around -0.5 pp, but also not statistically significant. Solvency ratios, shown in Column 4, exhibit no systematic change. However, the number of yearly environmental incidents in Column 5 decreases by about 1 incident or

38% relative to the sample mean. This result indicates some reputational benefits associated with the adoption of coal policies. Overall, given the small samples, limited time period, and the fact that insurer-level outcomes reflect many activities beyond coal underwriting, we can provide only limited evidence of insurer-level consequences. Nevertheless, our analysis highlights that coal policies have discernible effects within insurers' coal business and their relationships with coal mines.

6 Conclusion

Insurance companies can facilitate the net-zero transition by restricting insurance coverage of carbon-intensive projects. We study the design, determinants, implementation, and real effects of insurers' carbon underwriting policies. While such policies have become increasingly common, their design, adoption, and implementation remain highly heterogeneous. Using novel mine-level insurance data, we show that coal underwriting policies reduce coverage of U.S. coal mines, lower insured coal volumes, and make it less likely that existing mine-insurer relationships continue. Mines affected by changes in coverage are more likely to be abandoned and reduce scale, suggesting that underwriting decisions provide a viable channel through which the financial sector can influence decarbonization. Our findings provide the first systematic evidence on insurers' carbon underwriting policies and underscore that their effectiveness depends critically on policy design and implementation. We illustrate how a simple insurance-supply model with non-actuarial costs can rationalize these empirical patterns. Our results also highlight the role of market structure: in fragmented markets, substitution limits the reach of individual insurers' actions, whereas dependency on single insurers magnifies policy effects.

Table A.1: Variable definitions

Variable	Definition	Source
	Panel A: Insurer characteristics	
Coal policy	Equals one for insurers with a coal underwriting policy in place in a year, and zero for insurers without a coal underwriting policy	IOF scorecards
Coal policy score	Score ranging from 0 to 10 to reflect the stringency of a coal underwriting policy of an insurer in a year. Higher values indicate stricter policies	IOF scorecards
First coal policy score	An insurer's *Coal policy score* at adoption of the policy. For insurers that adopted a policy in 2017, we use the 2018 stringency scores.	IOF scorecards
Max coal policy score	Maximum of *Coal policy score* for an insurer	IOF scorecards
Oil & gas policy	Equals one for insurers with an oil & gas underwriting policy in a year, and zero for insurers without an oil & gas underwriting policy	IOF scorecards
Oil & gas policy score	Score ranging from 0 to 10 to reflect the stringency of an oil & gas underwriting policy of an insurer in a year. Higher values indicate stricter policies	IOF scorecards
Coal investment policy	Equals one for insurers with a coal investment policy in place in a year, and zero for insurers without a coal underwriting policy	IOF scorecards
Coal investment score	Score ranging from 0 to 10 to reflect the stringency of a coal investment policy of an insurer in a year. Higher values indicate stricter policies	IOF scorecards
Oil & gas investment policy	Equals one for insurers with an oil & gas investment policy in a year, and zero for insurers without an oil & gas investment policy	IOF scorecards
Oil & gas investment score	Score ranging from 0 to 10 to reflect the stringency of an oil & gas investment policy of an insurer in a year. Higher values indicate stricter policies	IOF scorecards
CCPI	Yearly Climate Change Performance Index score of an insurer's headquarters country. Insurers headquartered in the Bermuda territory are given the United Kingdom score.	CCPI website
NZIA	Equals one if an insurer (parent company of an insurance group) is a member of the Net Zero Insurance Alliance (NZIA) in a year, and zero otherwise	NZIA website
Specialty insurer	Equals one if an insurer (parent company of an insurance group) is a specialty insurer, and zero otherwise	Online searches
Unlisted insurer	Equals one if the parent company of an insurance group is unlisted, and zero otherwise	Orbis
High fossil fuel GWP share	Equals one if an insurer has a gross written premium to fossil fuels over 2022 total gross written premium above the median, and zero otherwise	IOF scorecards
Total assets	Consolidated total assets of the insurer in a year	Orbis
ROA (%)	Consolidated pre-tax return on assets of the insurer in a year	Orbis
GWP (log)	Gross written premiums of the insurer in a year	Orbis
CAR[0,1]	Sum of daily abnormal returns on the day of the announcement of the adoption of a carbon underwriting policy and the following trading day, where daily abnormal returns equal an insurer's stock return minus the market return	Compustat Global and Kenneth French Data Library
Solvency ratio	Solvency capital in a year, computed as the sum of capital and surplus, claims equalization reserve, and unrealized gains on investments, over total assets	Orbis
# RepRisk incidents	Number of environmental incidents in a year	RepRisk
# Coal mines insured	Number of unique coal mines insured in a quarter	Certificates of Liability Insurance

Coal volume insured	Million short tons (MMst) of coal produced by the mines insured in a quarter	Certificates of Liability Insurance
	Panel B: Policy characteristics	
Commercial general liability	Equals one if a policy covers commercial general liability, and zero otherwise	Certificates of Liability Insurance
Automobile	Equals one if a policy covers automobile liability, and zero otherwise	Certificates of Liability Insurance
Umbrella & excess	Equals one if a policy covers Umbrella or excess liability, and zero otherwise	Certificates of Liability Insurance
Workers compensation	Equals one if a policy covers workers compensation and employers' liability, and zero otherwise	Certificates of Liability Insurance
	Panel C: Insurer-mine relationship characteristics	
Coal policy	Equals one for quarters in which the insurer has a coal underwriting policy in place, and zero otherwise	IOF scorecards and Certificates of Liability Insurance
Inactive insurance	Equals one for quarters in which the insurer does not insure the mine, zero if it does	Certificates of Liability Insurance
Length active insurance	Time in quarters since which the insurer insures the mine	Certificates of Liability Insurance
	Panel D: Mine characteristics	
Coal policy exposed	Equals one if, between 2014 and 2016, a mine is insured by an insurer that subsequently adopted a coal underwriting policy, and zero otherwise	IOF scorecards and Certificates of Liability Insurance
Share coal policy exposed	Equals $\sum_i w_{m,i} \times \textit{Post coal policy}_{i,t}$ for a mine-quarter, where i indexes an insurer, m a mine and t a quarter. w are equal weights allocated to each insurer with at least eight quarters of active insurance relationship with a mine between 2014 and 2016, and *Post coal policy* equals one for insurer-quarters after a coal underwriting policy is introduced, and zero otherwise.	IOF scorecards and Certificates of Liability Insurance
Non-renewed insurance	Equals one if, in a quarter, the insurance coverage of a given mine by an insurer is not renewed, and zero if all insurers maintain coverage.	Certificates of Liability Insurance
Abandoned	Equals one if mine status in a quarter is either abandoned or abandoned and sealed, and zero otherwise	MSHA
Production	Million short tons (MMst) of coal produced by a mine in a quarter	MSHA
# Employees	Average number of employees of a mine in a quarter	MSHA
# Insurers per quarter	Number of different insurers of a mine in a quarter	Certificates of Liability Insurance
Relationship insurer	Equals one if a mine has a relationship of eight quarters or more with at least one insurer between 2014 and 2016, and zero otherwise	Certificates of Liability Insurance
Many insurers	Equals one if a mine has an above-median average number of insurers between 2014 and 2016, and zero otherwise	Certificates of Liability Insurance
Productive mine	Equals one if a mine has an above-median average quarterly output per working hour between 2014 and 2016, and zero otherwise	MSHA
Large mine	Equals one if a mine has an above-median total coal production between 2014 and 2016, and zero otherwise	MSHA

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Figure 1: Adoption and design of coal underwriting policies over time

The figure shows the number of insurers whose coal underwriting policies incorporate specific policy features. The sample is based on annual scorecards compiled by Insure Our Future (IOF) and includes up to 25 insurers with coal underwriting policies in place.

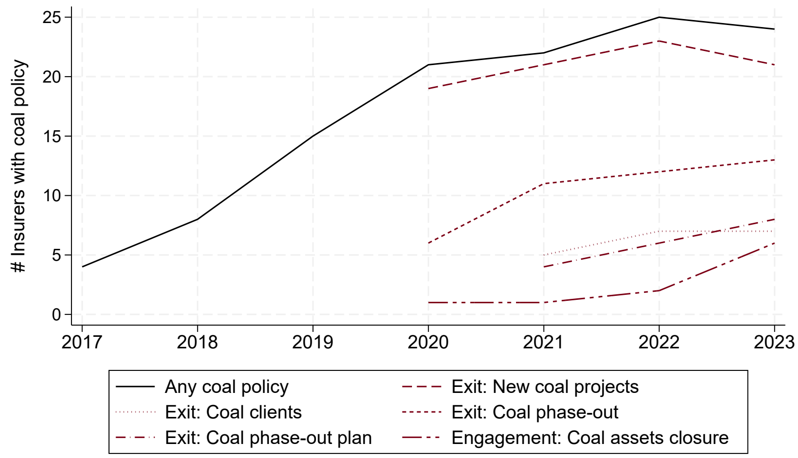


Figure 2: Stringency of coal underwriting policies over time

The figure displays scores capturing the stringency of coal underwriting policies over time. Scores range from 0 to 10, with higher values indicating more restrictive policies. Each dot represents an individual insurer in a given year. The solid line connects average scores by year. The two insurers with the highest and lowest overall carbon policy scores in the final sample year (2023) are highlighted with colored dots. The sample is based on annual scorecards compiled by Insure Our Future (IOF) and includes 25 insurers with coal underwriting policies in place.

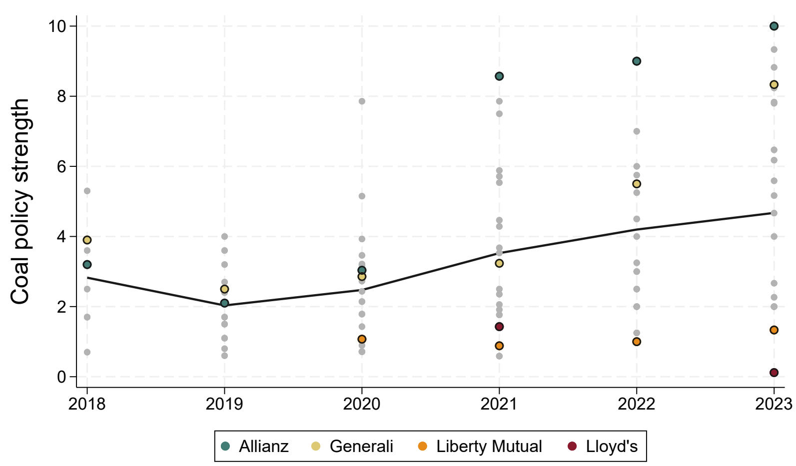


Figure 3: Coal mines' insurance status and underwriting policies

This figure displays coefficient estimates and 90% confidence intervals from the following OLS regression:

$$Inactive\ insurance_{s,m,i,t} = \sum_{t=-6}^{t=6} \beta_t \times Coal\ policy_i \times Event\ quarter_{s,t} + \alpha_{s,m,i} + \alpha_{s,m,t} + \epsilon_{s,m,i,t},$$

where s indexes a stack, m indexes a mine, i an insurer, and t a quarter. The dependent variable, *Inactive insurance*, equals one if an insurer does not insure a mine in a given quarter, and zero if it does. *Coal policy* equals one for insurer-mine pairs involving a policy-adopting insurer, and zero otherwise. *Event quarter* are dummy variables indicating quarters relative to the policy adoption quarter. $\alpha_{s,m,i}$ are stack-mine-insurer fixed effects, while $\alpha_{s,m,t}$ are stack-mine-time fixed effects. The initial sample includes all coal mines that appear in MSHA's Mine Data Retrieval System between 2014Q1 and 2024Q2, report at least one quarter of non-zero production, and have insurance certificate data available for those quarters. For each insurer that adopts a coal underwriting policy, we identify all mines it insures and construct a balanced sample of 13 quarterly observations per mine-insurance pair, six before and six after the policy adoption quarter, whenever information on the liability insurance certificates of a given mine is available. These mine-insurer pairs form the treated relationships in the stack. As a control group, we include all other relationships that the same mines have with insurers that never adopt a coal underwriting policy. Standard errors are clustered at the insurer-stack level. Table A.1 provides descriptions of all variables.

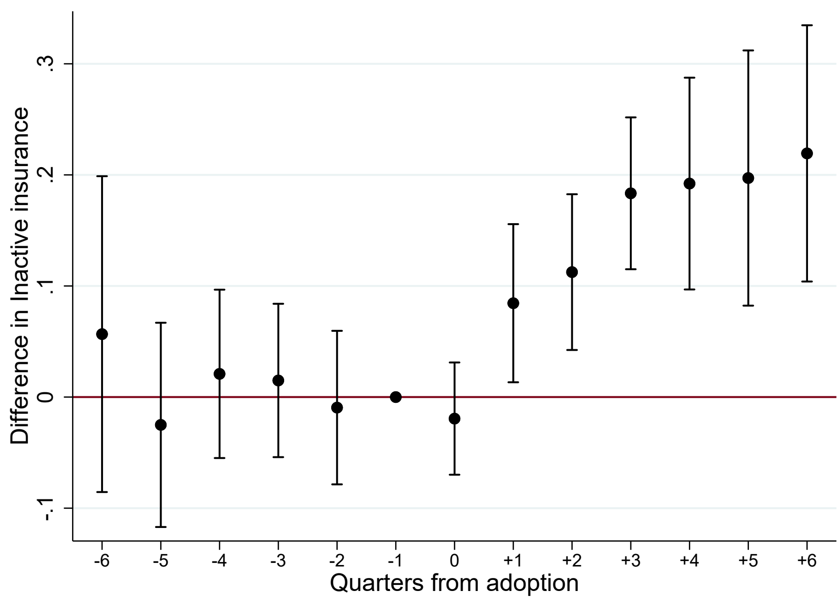


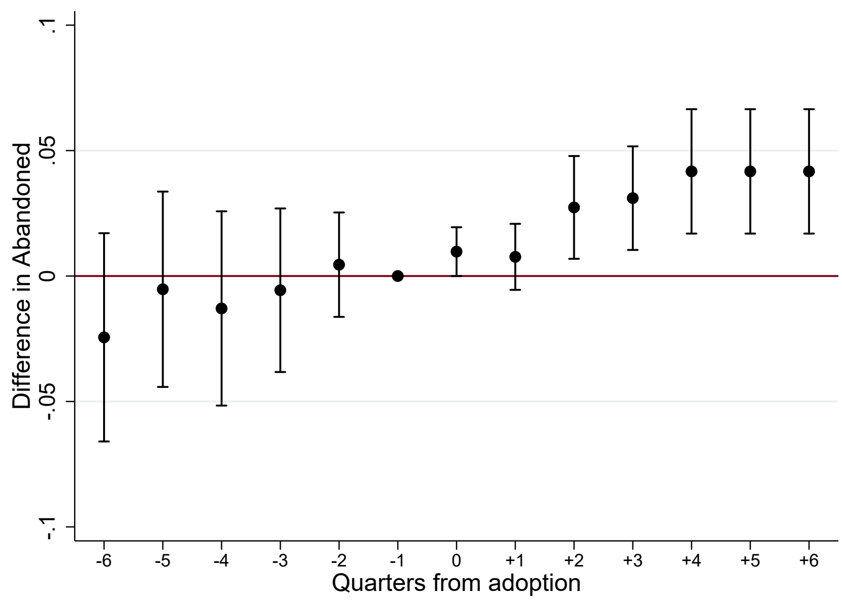
Figure 4: Coal mine outcomes and underwriting policies

This figure displays coefficient estimates and 90% confidence intervals from the following OLS regression:

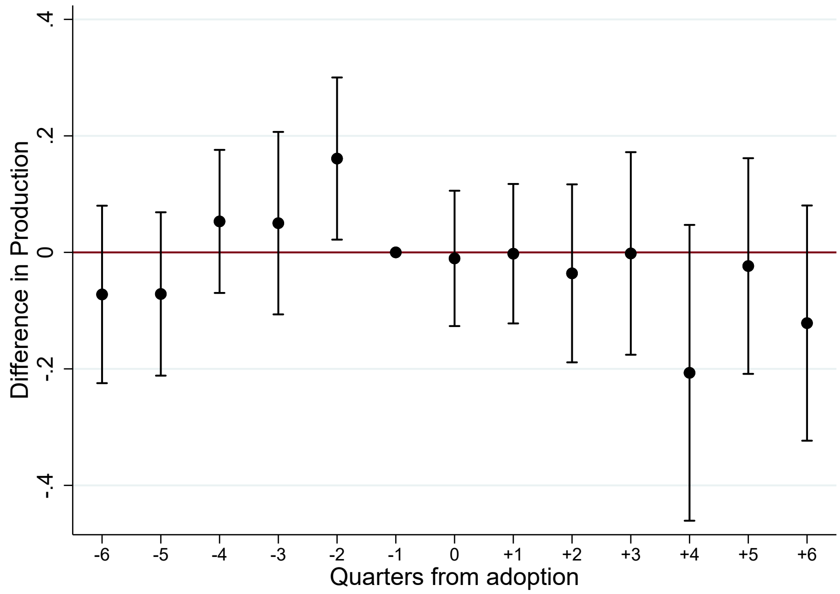
$$Coal\ mine\ outcome_{s,m,t} = \sum_{t=-6}^{t=6} \beta_t \times Coal\ policy\ exposed_{s,m} \times Event\ quarter_{s,t}\ + \alpha_{s,m} + \alpha_{s,t} + \epsilon_{s,m,t},$$

where s indexes a stack, m a mine, and t a quarter. The dependent variable, *Coal mine outcome*, is a dummy variable indicating whether a mine is abandoned (Panel A), the volume of coal produced (Panel B), or the average number of employees (Panel C). *Coal policy exposed* equals one for mines that, between 2014 and 2016, are insured by an insurer that subsequently adopted a coal underwriting policy, and zero otherwise. *Event quarter* are dummy variables indicating quarters relative to the policy adoption quarter. If a mine is exposed to multiple such adoptions, only the first instance is used to define treatment. The sample includes all mines from Table 4, provided that we successfully obtained Certificates of Liability Insurance on ACORD 25 forms from state-level agencies between 2014 and 2016. In Panels B and C, the sample includes only mines that are active throughout the entire sample period. Standard errors are clustered at the mine-stack level. Table A.1 provides descriptions of all variables.

Panel A: Abandoned



Panel B: Production



Panel C: # Employees

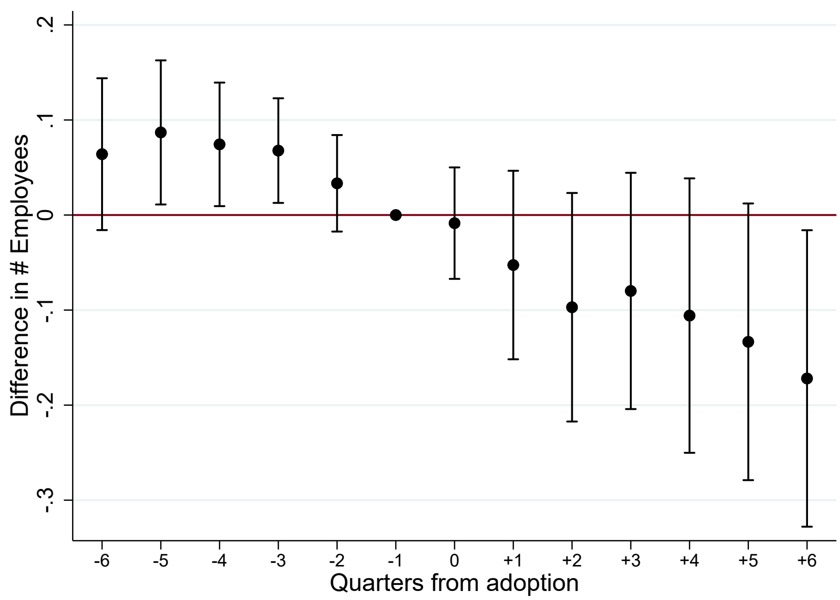


Table 1: Determinants of coal underwriting policies

This table presents results from the following OLS regression:

$$Y_{i,t} = \beta \times X_{i,t-1} + \alpha_t + \epsilon_{i,t},$$

where i indexes an insurer and t a year. In Column 1, the dependent variable, Y, is *Coal policy*, which equals one if the insurer has a coal underwriting policy, and zero otherwise. In Column 2, Y is *Coal policy score*, which is a score ranging from 0 to 10, with higher scores indicating stricter coal underwriting policies. X is a vector of insurer-level characteristics. The sample is based on annual scorecards compiled by Insure Our Future (IOF); Column 2 additionally conditions on insurers with a policy in place. Standard errors are clustered at the insurer level and reported in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. Table A.1 provides descriptions of all variables.

	Coal policy	*Coal policy score*
	(1)	(2)
CCPI	0.009**	0.077***
	(0.004)	(0.022)
NZIA	0.013	1.935**
	(0.092)	(0.708)
Specialty insurer	-0.313**	-0.518
	(0.146)	(0.969)
Unlisted insurer	-0.419***	-2.403*
	(0.137)	(1.243)
High fossil fuel GWP share	-0.222**	0.454
	(0.094)	(0.735)
Total Assets (log)	-0.005	-0.201
	(0.050)	(0.336)
ROA	-0.037*	-0.242*
	(0.019)	(0.141)
Time FE	Yes	Yes
Obs.	180	115
Adj. R^2	0.404	0.477
# Insurers in sample	32	25

Table 2: Descriptive statistics on coal mines and underwriting policies

This table presents descriptive statistics on coal mines and underwriting policies. The sample includes all coal mines listed in MSHA's Mine Data Retrieval System between 2014Q1 and 2024Q2, provided they report at least one quarter of non-zero coal production, and for which we successfully obtained Certificates of Liability Insurance on ACORD 25 forms from state-level agencies. In Panel A, the sample is at the mine-quarter-insurer level. In Panel B, the sample is collapsed at the insurer-quarter level. In Panel C, the sample is collapsed at the mine-quarter level. Table A.1 provides descriptions of all variables.

	Obs.	Mean	Std.	25th	Median	75th
Panel A: Insurer-mine-quarter sample						
Coal policy	51,710	0.47				
Inactive insurance	51,710	0.57				
Length active insurance (quarters)	51,710	14.20	8.91	8.00	12.00	19.00
Panel B: Insurer-quarter sample						
Coal policy	1,145	0.28				
# Coal mines insured	1,145	19.61	33.65	2.00	4.00	16.00
Coal volume insured (MMst)	1,145	5.94	10.85	0.04	1.13	4.91
Panel C: Mine-quarter sample						
Coal policy exposed	10,883	0.80				
Non-renewed insurance	12,812	0.07				
Share coal policy exposed	7,342	0.25	0.40	0.00	0.00	0.50
Abandoned mine	12,812	0.11				
Production (MMst)	12,812	0.35	1.68	0.00	0.00	0.12
# Employees	12,812	71.40	147.91	0.00	9.00	78.00
# Insurers per quarter	12,812	4.15	1.84	3.00	4.00	5.00
Relationship insurer	12,932	0.57				
Many insurers	11,254	0.45				
Productive mine	10,129	0.50				
Large mine	11,254	0.50				

Table 3: Insurers' coal underwriting activity and underwriting policies

This table presents results from the following OLS regression:

$$Coal\ insurance_{i,t} = \beta \times Post\ coal\ policy_{i,t} + \alpha_i + \alpha_t + \epsilon_{i,t},$$

where i indexes an insurer and t a quarter. In Columns 1 and 3, the dependent variable, *Coal insurance*, is *# Coal mines insured*, which is the number of mines insured by an insurer in a given quarter. In Columns 2 and 4, *Coal insurance* is *Coal volume insured*, which is the volume of insured coal that is produced. *Post coal policy* equals one for insurer-quarters after a coal underwriting policy is introduced, and zero otherwise. The sample includes all coal mines listed in MSHA's Mine Data Retrieval System between 2014Q1 and 2024Q2, provided they report at least one quarter of non-zero coal production, and for which we successfully obtained Certificates of Liability Insurance on ACORD 25 forms from state-level agencies. In Columns 3 and 4, the sample includes only mines that are active throughout the entire sample period. Robust standard errors are reported in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. Table A.1 provides descriptions of all variables.

	# Coal mines insured (log)	*Coal volume insured* (log)	*# Coal mines insured* (log)	*Coal volume insured* (log)
	All coal mines		Active coal mines	
	(1)	(2)	(3)	(4)
Post coal policy	-0.172**	-0.824***	-0.582***	-0.651***
	(0.080)	(0.145)	(0.085)	(0.152)
Insurance group FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Obs.	1,145	951	680	671
Adj. R^2	0.828	0.767	0.750	0.754
# Insurance groups	46	40	29	28

Table 4: Coal mines' insurance status and underwriting policies

This table presents results from the following OLS regression:

$$Inactive\ insurance_{s,m,i,t} = \beta \times Coal\ policy_i \times Post_{s,t} + \alpha_{s,m,i} + \alpha_{s,m,t} + \epsilon_{s,m,i,t},$$

where s indexes a stack, m a mine, i an insurer, and t a quarter. The dependent variable, *Inactive insurance*, equals one if an insurer does not insure a mine in a given quarter, and zero if it does. *Coal policy* equals one for insurer-mine pairs involving a policy-adopting insurer, and zero otherwise. *Post* equals one for the quarter of the adoption of coal policy and all quarters thereafter, and zero otherwise. The initial sample includes all coal mines that appear in MSHA's Mine Data Retrieval System between 2014Q1 and 2024Q2, report at least one quarter of non-zero production, and have insurance certificate data available for those quarters. For each insurer that adopts a coal underwriting policy, we identify all mines it insures and construct a balanced sample of 13 quarterly observations per mine-insurance pair, six before and six after the policy adoption quarter, whenever information on the liability insurance certificates of a given mine is available. These mine-insurer pairs form the treated observations in the stack. As control observations, we include all other mine-insurer pairs that include the same mines but insurers that never adopt a coal underwriting policy. In Column 2, the sample includes only mines that are active throughout the entire sample period. Standard errors are clustered at the insurer-stack level and reported in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. Table A.1 provides descriptions of all variables.

	Inactive insurance	
	All coal mines	Active coal mines
	(1)	(2)
Coal policy × *Post*	0.128**	0.137**
	(0.055)	(0.066)
Stack × Insurance group × Coal mine FE	Yes	Yes
Stack × Coal mine × Time FE	Yes	Yes
Obs.	24,907	4,330
Adj. R^2	0.587	0.604
# Insurance groups	46	26

Table 5: Cross-sectional variation in changes in underwriting activity

In Columns 1 and 2, this table presents variants of the following OLS regression:

$$Inactive\ insurance_{s,m,i,t} = \beta \times Coal\ policy\ score_i \times Post_{s,t} + \alpha_{s,m,i} + \alpha_{s,m,t} + \epsilon_{s,m,i,t},$$

while Columns 3 and 4 present variants of the following OLS regression:

$$\begin{aligned} Inactive\ insurance_{s,m,l,i,t} =& \beta_1 \times Coal\ policy_i \times Post_{s,t} \times Insurance\ line_l + \beta_2 \times Coal\ policy_i \times Post_{s,t} \\ &+ \alpha_{s,m,l,i} + \alpha_{s,m,t} + \epsilon_{s,m,l,i,t}, \end{aligned}$$

where s indexes a stack, m a mine, l an insurance line, i an insurer, and t a quarter. The dependent variable, *Inactive insurance*, equals one if an insurer does not insure a mine in a given quarter, and zero if it does. *Coal policy* equals one for mines insured by an insurer adopting a carbon underwriting policy, and zero otherwise. *Post* equals one for the quarter of the adoption of coal policy and all quarters thereafter, and zero otherwise. The initial sample of mines includes all coal mines listed in MSHA's Mine Data Retrieval System between 2014Q1 and 2024Q2, provided they report at least one quarter of non-zero coal production, and for which we successfully obtained Certificates of Liability Insurance on ACORD 25 forms from state-level agencies. For Columns 1 and 2, we define the unit of observation as a mine-insurer pair. For each insurer that adopts a coal underwriting policy, we identify all mines it insures and construct a balanced sample of 13 quarterly observations per pair—six before and six after the policy adoption quarter—whenever liability insurance certificate data are available. These mine-insurer pairs form the treated observations in the stack. As controls, we include all other mine-insurer pairs involving the same mines but insurers that never adopt a coal underwriting policy. Standard errors are clustered at the insurer-stack level. For Columns 3 and 4, we repeat this procedure at the finer level of mine-insurance line-insurer triplets. That is, we construct balanced panels of 13 quarterly observations per triplet and stack them analogously. Standard errors are clustered at the insurer-insurance line-stack level and reported in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. Table A.1 provides descriptions of all variables.

Table 5: (continued)

	Inactive insurance			
	(1)	(2)	(3)	(4)
First coal policy score × *Post*	0.042*			
	(0.023)			
Max coal policy score × *Post*		0.026***		
		(0.010)		
Coal policy × *Post*			0.087*	0.125**
			(0.047)	(0.059)
Coal policy × *Post* × *Automobile*				-0.040
				(0.084)
Coal policy × *Post* × *Umbrella & excess*				-0.072
				(0.100)
Coal policy × *Post* × *Workers compensation*				-0.135*
				(0.079)
Post × *Automobile*				0.011
				(0.081)
Post × *Umbrella & excess*				0.029
				(0.065)
Post × *Workers compensation*				-0.042
				(0.063)
Stack × Insurance group × Coal mine FE	Yes	Yes		
Stack × Coal mine × Time FE	Yes	Yes		
Stack × Insurance group × Coal mine × Insurance type FE			Yes	Yes
Stack × Coal mine × Time FE			Yes	Yes
Obs.	24,907	24,907	41,615	41,615
Adj. R^2	0.585	0.585	0.623	0.625
# Insurance groups	46	46	46	46

Table 6: Coal mine outcomes and insurance non-renewal

This table presents results from the following OLS regression estimated at the mine-quarter level:

$$\textit{Coal mine outcome}_{m,t} = \sum_{k=1}^{k=4} \beta_k \times \textit{Non-renewed insurance}_{m,t-k} + \alpha_m + \alpha_t + \epsilon_{m,t}$$

where m indexes a mine and t a quarter. The dependent variable, *Coal mine outcome*, is a dummy variable indicating whether a mine is abandoned (Column 1), the volume of coal produced (Column 2), or the average number of employees (Column 3). *Non-renewed insurance* equals one if in quarter $t-k$, with $k \in [1,4]$, at least one insurer of mine m does not renew its coverage, it equals zero as long as insurance coverage for mine m by the set of its insurers exists and is renewed. The sample includes all coal mines that appear in MSHA's Mine Data Retrieval System between 2014Q1 and 2024Q2, report at least one quarter of non-zero production, and have insurance certificate data available for those quarters. In Columns 2 and 3, the sample includes only mines that are active throughout the entire sample period. Standard errors are clustered at the mine level and reported in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. Table A.1 provides descriptions of all variables.

	Abandoned	*Production (log)*	*# Employees (log)*
	(1)	(2)	(3)
Non-renewed insurance$_{t-1}$	0.003	-0.066	-0.048*
	(0.007)	(0.059)	(0.027)
Non-renewed insurance$_{t-2}$	0.002	-0.112**	-0.112***
	(0.007)	(0.054)	(0.040)
Non-renewed insurance$_{t-3}$	0.006	-0.043	-0.082*
	(0.008)	(0.047)	(0.043)
Non-renewed insurance$_{t-4}$	0.014*	-0.088	-0.086*
	(0.008)	(0.064)	(0.046)
Coal mine FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Obs.	12,812	2,173	2,256
Adj. R^2	0.601	0.911	0.911
# Coal mines	456	62	63

Table 7: Coal mine outcomes and underwriting policies

This table presents results from the following OLS regression estimated at the mine-quarter level:

$$Coal\ mine\ outcome_{s,m,t} = \beta \times Coal\ policy\ exposed_m \times Post_{s,t} + \alpha_{s,m} + \alpha_{s,t} + \epsilon_{s,m,t}$$

where s indexes a stack, m a mine, and t a quarter. The dependent variable, *Coal mine outcome*, is a dummy variable indicating whether a mine is abandoned (Column 1), the volume of coal produced (Column 2), or the average number of employees (Column 3). *Coal policy exposed* equals one for mines that, between 2014 and 2016, are insured by an insurer that subsequently adopted a coal underwriting policy, and zero otherwise. *Post* equals one for the first and all subsequent quarters following the earliest quarter in which the insurer of the mine adopted a coal underwriting policy. If a mine is exposed to multiple such adoptions, only the first instance is used to define treatment. The sample includes all mines from Table 4. In Columns 2 and 3, the sample includes only mines that are active throughout the entire sample period. Standard errors are clustered at the mine-stack level and reported in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. Table A.1 provides descriptions of all variables.

	Abandoned	*Production (log)*	*# Employees (log)*
	(1)	(2)	(3)
Coal policy exposed × *Post*	0.036*	-0.078	-0.147**
	(0.018)	(0.082)	(0.069)
Stack × Coal mine FE	Yes	Yes	Yes
Stack × Time FE	Yes	Yes	Yes
Obs.	5,525	932	936
Adj. R^2	0.835	0.912	0.947
# Coal mines	270	57	57

Table 8: Cross-sectional variation in changes in coal mine outcomes

This table presents results from the following OLS regression estimated at the mine-quarter level:

$$\begin{aligned} \textit{Coal mine outcome}_{s,m,t} &= \beta_1 \times \textit{Coal policy exposed}_m \times \textit{Post}_{s,t} + \\ &\beta_2 \times \textit{Coal policy exposed}_m \times \textit{Post}_{s,t} \times X_m + \beta_3 \times \textit{Post}_{s,t} \times X_m + \alpha_{s,m} + \alpha_{s,t} + \epsilon_{s,m,t} \end{aligned}$$

where s indexes a stack, m a mine, and t a quarter. The dependent variable, *Coal mine outcome*, is a dummy variable indicating whether a mine is abandoned. *Coal policy exposed* equals one for mines that, between 2014 and 2016, are insured by an insurer that subsequently adopted a coal underwriting policy, and zero otherwise. *Post* equals one for the first and all subsequent quarters following the earliest quarter in which the insurer of the mine adopted a coal underwriting policy. If a mine is exposed to multiple such adoptions, only the first instance is used to define treatment. X is a mine-level dummy variable. In Column 1, X is *Relationship insurer*, defined as one if the mine has at least one insurer that provided coverage for eight quarters or more during 2014-2016. In Column 2, X is *Many insurers*, defined as one if the mine has an above-median number of distinct insurers during 2014-2016. In Column 3, X is *Productive mine*, defined as one if the mine has above-median average productivity (output per working hour) during 2014-2016. In Column 4, X is *Large mine*, defined as one if the mine has above-median total coal production during 2014-2016. The sample includes all mines from Table 4. Standard errors are clustered at the mine-stack level and reported in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. Table A.1 provides descriptions of all variables.

	Abandoned			
	(1)	(2)	(3)	(4)
Coal policy exposed × Post	-0.016	0.051***	0.033	0.011
	(0.030)	(0.019)	(0.024)	(0.030)
Coal policy exposed × Post × Relationship insurer	0.076**			
	(0.032)			
Post × Relationship insurer	-0.034*			
	(0.018)			
Coal policy exposed × Post × Many insurers		-0.057*		
		(0.033)		
Post × Many insurers		0.006		
		(0.011)		
Coal policy exposed × Post × Productive mine			0.001	
			(0.032)	
Post × Productive mine			-0.030*	
			(0.016)	
Coal policy exposed × Post × Large mine				0.036
				(0.030)
Post × Large mine				0.007
				(0.011)
Stack × Coal mine FE	Yes	Yes	Yes	Yes
Stack × Time FE	Yes	Yes	Yes	Yes
Obs.	5,525	5,525	4,836	5,525
Adj. R^2	0.836	0.836	0.845	0.836
# Coal mines	425	425	372	425

Table 9: Insurer-level outcomes and coal underwriting policies

This table presents results from the following OLS regression:

$$Y_{i,t} = \beta_1 \times Coal\,policy_{i,t-1} + \alpha_i + \alpha_t + \epsilon_{i,t},$$

where i indexes an insurer and t year. The dependent variable, Y, is gross written premiums (Column 1), return on assets (Column 2), two-day cumulative abnormal returns around the announcement of policy adoptions (Column 3), solvency ratio (Column 4), or the number of RepRisk environmental incidents (Column 5). *Coal policy* equals one for quarters in which the insurer has a coal underwriting policy in place, and zero otherwise. α_i are insurer fixed effects and α_t are year fixed effects. The sample in Columns 1, 2, 4, and 5 is a firm-year panel based on annual scorecards compiled by Insure Our Future (IOF), while the sample in Column 3 includes all 18 listed insurers that adopt a coal underwriting policy. Standard errors in Columns 1, 2, 4, and 5 are clustered at the insurer level and reported in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. Table A.1 provides descriptions of all variables.

	GWP (log)	*ROA*	*CAR[0,1]*	*Solvency ratio*	*# RepRisk incidents*
	(1)	(2)	(3)	(4)	(5)
Coal policy	-0.002	-0.471		-0.156	-0.963**
	(0.030)	(0.395)		(0.476)	(0.427)
Constant			-0.526		
			(0.450)		
Time FE	Yes	Yes	No	Yes	Yes
Insurance group FE	Yes	Yes	No	Yes	Yes
Obs.	130	133	18	133	146
Adj. R^2	0.993	0.363	0.000	0.983	0.749
# Insurers in sample	28	29	18	29	29

Online Appendix to

Insurers' Carbon Underwriting Policies

A. Insurance Supply Model with Non-actuarial Costs

A.1 Motivation

Our empirical analysis in Section 2.3 indicates that the adoption and stringency of carbon underwriting policies are positively associated with proxies for pressure by various stakeholder groups, such as retail customers, employees, peers, investors, or the broader public. Rationalizing these patterns requires modeling insurance supply in a way that goes beyond the standard framework of Koijen and Yogo (2023a), in which the underwriting decision of insurers is modeled to reflect expected losses, regulatory reserves, the marginal cost of capital, and other standard pricing components such as markups. Specifically, it appears that in the context of carbon-intensive assets, insurers face additional non-actuarial costs resulting from stakeholder pressure that shape their willingness to underwrite risks.[24] Examples of non-actuarial costs not reflected in the risk-based underwriting decision include reputational damage, brand erosion, "loss of license to operate," or talent attraction and retention problems, all of which arise in response to pressure by various stakeholders.

To guide our empirical analysis and understand the implications of these additional costs, we augment the standard insurance-supply model with (i) a fixed non-actuarial penalty for maintaining any coal exposure (fixed cost) and (ii) a per-unit non-actuarial cost of underwriting coal-related risks (marginal cost).[25] The first cost type is not a cost of adopting a climate policy *per se*, but arises when underwriting behavior contradicts an insurer's own publicly stated climate policy or commitment. Once an insurer underwrites any coal-related coverage in violation of such commitment, the fixed penalty is incurred, independent of the scale of the underwriting exposure (one can think of it as a fixed cost of greenwash-

[24] As "non-actuarial" costs, we consider factors that enter into the decision problem of an insurer *on top of* factors related to risk-based pricing and expected losses, following the modeling approach of Koijen and Yogo (2023a). In our framework, expected losses, regulatory reserves, capital requirements, and other standard pricing components such as markups capture actuarial costs of underwriting decisions that are directly tied to the actuarial risk of the insured object and priced through the underwriting contract. By contrast, the costs we label non-actuarial do not reflect the insured risk itself and do not operate through expected losses or capital requirements, even though they may ultimately have financial consequences for the insurer.

[25] A unit of coverage can be interpreted broadly. For example, it may correspond to an insured mine-insurance line combination (e.g., a general liability insurance certificate for mine A or a workers' compensation certificate for mine B), but it could also represent finer or coarser measures of insured exposure, such as coverage volume or mine size. The precise definition of a unit is not material for the model's qualitative predictions.

ing). Instead, the second cost type reflects costs associated with stakeholder pressure that increase with an insurer's overall coal exposure, as greater coal involvement attracts more sustained attention and pressure from stakeholders (one can think of it as a rising fraction of retail customers with green preferences that shy away from an insurer as the coal exposure increases). Notably, both types of costs can have financial consequences for insurers and should therefore affect their decision-making.

This adjusted model delivers several key mechanisms relevant to our empirical setting. First, insurer-specific differences in these two types of non-actuarial costs imply heterogeneous withdrawal intensities across insurers. Second, the fixed non-actuarial penalty associated with maintaining any coal exposure (once a policy is in place) can generate abrupt non-renewals or full relationship terminations, rather than gradual retrenchment. Third, the per-unit non-actuarial cost raises the marginal cost of insuring lines more directly tied to core coal extraction activities, producing selective reductions in coverage. Fourth, because mines require a minimum level of liability coverage to operate, reductions in coverage can trigger mine closure when total available coverage falls below a regulatory threshold required to operate a mine. Fifth, the extent to which withdrawal translates into real effects depends on insurer substitutability. The reason is that mines that rely heavily on a single insurer are most exposed to coverage losses because insurance supply is not perfectly elastic. Replacing withdrawn coverage requires costly underwriting, and, under carbon underwriting policies, many insurers are unwilling or unable to expand coverage, limiting substitution even in the absence of strategic interaction.

A.2 The model

1. Insurers and coal mines. Coal mines $j \in J$ require liability insurance to operate and may obtain coverage from multiple insurers.

Insurers $i \in I$ choose premiums P_{ij} and coverage quantities Q_{ij}. Demand for insurer i's coverage is downward sloping,

$$Q_{ij} = Q_{ij}(P_{ij}), \qquad \frac{\partial Q_{ij}}{\partial P_{ij}} < 0,$$

and total available coverage for mine j is

$$Q_j^{\text{total}} = \sum_i Q_{ij}(P_{ij}).$$

Competition matters because $Q_{ij}(P_{ij})$ depends on the prices charged by alternative insurers through the elasticity of substitution across insurers (this elasticity reflects any unmodeled reduced-form limits to substitutability in insurance supply).

2. Losses, reserves, and capital requirements. Insurers are risk-neutral but face regulatory reserve requirements and costly risk-based capital, which act as reduced-form representations of risk considerations and generate effective risk aversion at the underwriting margin. Losses follow the random variable ℓ_{ij} with mean μ_{ij} and standard deviation σ_{ij}.

Regulatory reserves for insuring coal mine j by insurer i are

$$R_{ij} = \mu_{ij} + \kappa_i \sigma_{ij},$$

where $\kappa_i > 0$ reflects prudence in reserve setting.

Underwriting Q_{ij} units of exposure requires risk-based capital K_i for insurer i:

$$K_i = \sum_j \alpha_i R_{ij} Q_{ij},$$

where $\alpha_i > 0$ is a risk-based capital coefficient. Insurer i incurs a convex cost of capital,

$$\Phi_i(K_i) \qquad \Phi_i'(K_i) = \lambda_i > 0, \qquad \Phi_i''(K_i) > 0.$$

The convexity of $\Phi_i(\cdot)$ captures that the marginal cost of capital increases with the scale of underwriting. These reserve and capital requirements embed the effect of risk without requiring explicit curvature in insurers' utility functions.

3. Non-actuarial costs. We extend the model of Koijen and Yogo (2023a) to our setting by incorporating two forms of non-actuarial costs that arise from underwriting coal-mining-related insurance lines: a fixed penalty that is incurred whenever an insurer maintains any coal underwriting exposure and a marginal cost that scales with coal exposure. As mentioned above, these terms capture costs beyond standard risk-based underwriting costs associated with coal underwriting.

- *Fixed non-actuarial penalty.* Maintaining any coal exposure may trigger a fixed cost, reflecting stakeholder pressure unrelated to expected losses or capital requirements, such as fixed costs from reputational or credibility losses as a result of breaching public zero-coal underwriting commitments:

$$\Omega_i = \begin{cases} 0, & Q_{ij} = 0 \ \forall j, \\ F_i, & \exists j : Q_{ij} > 0. \end{cases}$$

  Here, $F_i > 0$ is increasing in the stringency of the insurer's public underwriting commitment, as captured by the policy score: insurers with stricter and more visible commitments to exit coal face larger reputational or credibility losses if those commitments are violated, operating as a fixed cost of maintaining any coal exposure.

- *Marginal non-actuarial cost.* Let j index insured exposure units (e.g., all mine-line combinations), and let e_j denote the coal-exposure intensity of unit j, reflecting how directly it is tied to core mining activities (e.g., commercial general liability coverage of the mine operations has high exposure intensity, and workers' compensation insurance of a mine has low exposure intensity). Insurer i's total coal-related exposure is

$$E_i = \sum_j e_j Q_{ij}.$$

  Non-actuarial costs from incremental coal exposure are captured by a convex cost function $\Psi_i(E_i)$ with $\Psi_i'(E_i) > 0$. This function reflects any costs related to stakeholders' pressure that increase with exposure.

4. Heterogeneity in coal exposure and policy stringency. Insurers differ in their non-actuarial cost functions $\Psi_i(\cdot)$ and in the fixed penalty F_i, reflecting variation in public commitments, regulatory pressure, stakeholder preferences, and existing carbon exposure. These differences imply heterogeneous marginal costs of underwriting identical lines. They also interact with competition: when insurers with high non-actuarial costs withdraw, remaining insurers face higher E_i if they replace lost coverage, limiting insurance substitutability and potentially amplifying the real effects of insurance coverage.

5. Insurer's problem. We express profits relative to a baseline in which the insurer underwrites no coal-related lines. Baseline profits from all non-coal business are normalized to zero, so Π_i represents the incremental profit from underwriting coal.

Each insurer chooses $\{P_{ij}\}$ to maximize profits:

$$\Pi_i = \sum_j (P_{ij} - \mu_{ij}) Q_{ij}(P_{ij}) \;-\; \Phi_i(K_i) \;-\; \Psi_i(E_i) \;-\; \Omega_i,$$

where $\Omega_i = F_i$ if the insurer underwrites any coal-related line and $\Omega_i = 0$ otherwise.

Let $\varepsilon_{ij} > 1$ denote the (absolute) elasticity of demand for insurer i's coverage for line j. For any line with strictly positive coverage ($Q_{ij} > 0$), the first-order condition yields a Lerner-type pricing rule:

$$\frac{P_{ij} - MC_{ij}}{P_{ij}} = \frac{1}{\varepsilon_{ij}},$$

where marginal cost is

$$MC_{ij} = \mu_{ij} + \lambda_i \alpha_i R_{ij} + \Psi_i'(E_i)\, e_j.$$

The fixed penalty F_i does not affect the marginal cost once the insurer has entered the coal market, because Ω_i is constant for all $Q_{ij} > 0$.

Entry condition. Relative to a baseline with no coal underwriting, entry requires

$$\Pi_i^{\text{enter}} \geq 0 \quad \Leftrightarrow \quad \sum_j (P_{ij} - \mu_{ij}) Q_{ij}(P_{ij}) \;-\; \Phi_i(K_i) \;-\; \Psi_i(E_i) \;-\; F_i \geq 0.$$

This implies that a sufficiently large fixed penalty F_i deters entry into coal underwriting entirely, leading the insurer to set $Q_{ij} = 0$ for all coal-related lines.

6. Mine continuation condition. Mines operate only if they meet the regulatory minimum required insurance coverage. Formally, mine j continues operating if

$$Q_j^{\text{total}} = \sum_i Q_{ij}(P_{ij}) \geq L_j,$$

where L_j denotes the mandated coverage threshold. The parameter L_j serves as a reduced-form representation of mines' operational need for insurance, rather than reflecting risk aversion.

Substitutability matters because the effect of one insurer's withdrawal depends on the mine's access to alternatives: if few insurers offer coverage, mine j is more likely to fall below L_j when one insurer withdraws.

A.3 Model predictions

The model yields several predictions that map directly into our empirical findings:

- *Policy adoption and enforcement.* Differences in $\Psi_i(\cdot)$ and F_i imply that insurers with more stringent public commitments to exit coal, captured by higher policy scores, implement these policies more stringently. This is because higher F_i raises the likelihood of full exit from coal underwriting, while higher $\Psi_i'(E_i)$ increases the marginal cost of maintaining coal exposure.
- *Heterogeneity across insurers.* Conditional on adoption, variations in $\Psi_i'(E_i)$ and F_i generate systematic differences in withdrawal intensity across insurers.
- *Selective withdrawal.* Coal-policy stringency enters marginal cost through $\Psi_i'(E_i)e_j$, so increases in $\Psi_i'(E_i)$ disproportionately raise the cost of insuring high-exposure lines:

  $$\frac{\partial P_{ij}}{\partial e_j} = m(\varepsilon_{ij})\Psi_i'(E_i).$$

  This leads insurers to reduce coverage for high-exposure lines, such as commercial general liability, while maintaining coverage for lines with lower exposure, such as workers' compensation.
- *Mine exit and real effects.* The continuation condition $\sum_i Q_{ij} \geq L_j$ links insurer

withdrawal directly to mine abandonment: operations cannot continue when available coverage falls below the regulatory threshold L_j.

- *Substitutability and entry deterrence.* Although the model does not explicitly model insurer coordination or strategic interaction, the continuation condition implies that the real effects of withdrawal depend on the availability of alternative insurers: mines that rely heavily on a small number of insurers are most vulnerable to falling below required coverage once one insurer withdraws. Substitution by existing insurers or entry by new insurers is limited because underwriting coal increases E_i and for entrants activates F_i.

B. Additional Figures and Tables

B.1 Additional Figures

Figure OA.1: Prevalence and design of oil & gas underwriting policies over time

The figure shows the number of insurers whose oil & gas underwriting policies incorporate specific policy features. The sample is based on annual scorecards compiled by Insure Our Future (IOF) and includes up to 22 insurers with oil & gas underwriting policies in place.

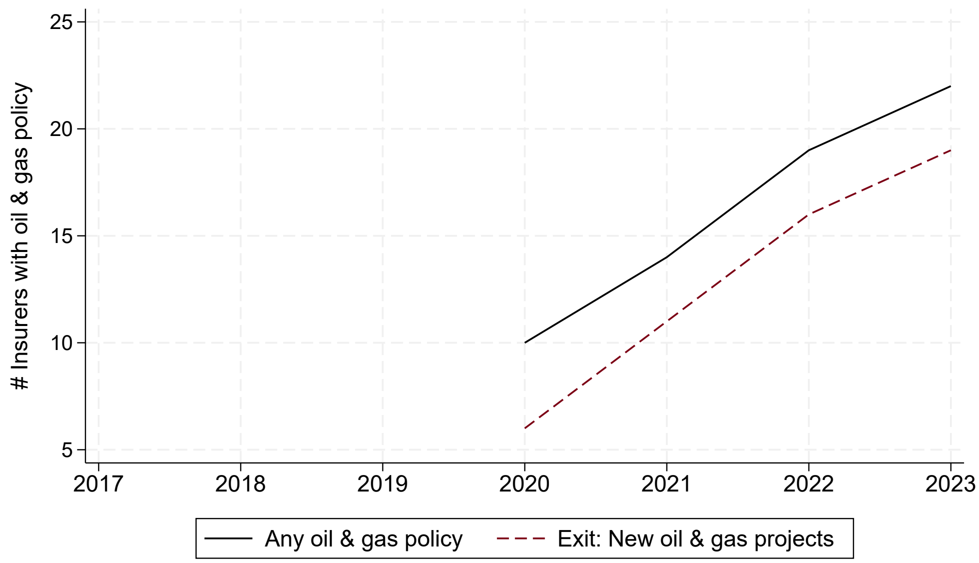


Figure OA.2: Stringency of oil & gas underwriting policies over time

The figure displays scores capturing the stringency of oil & gas underwriting policies over time. Scores range from 0 to 10, with higher values indicating more restrictive policies. Each dot represents an individual insurer in a given year. The solid line connects average scores by year. The two insurers with the highest and lowest overall carbon policy scores in the final sample year (2023) are highlighted with colored dots. The sample is based on annual scorecards compiled by Insure Our Future (IOF) and includes 22 insurers with oil & gas underwriting policies in place.

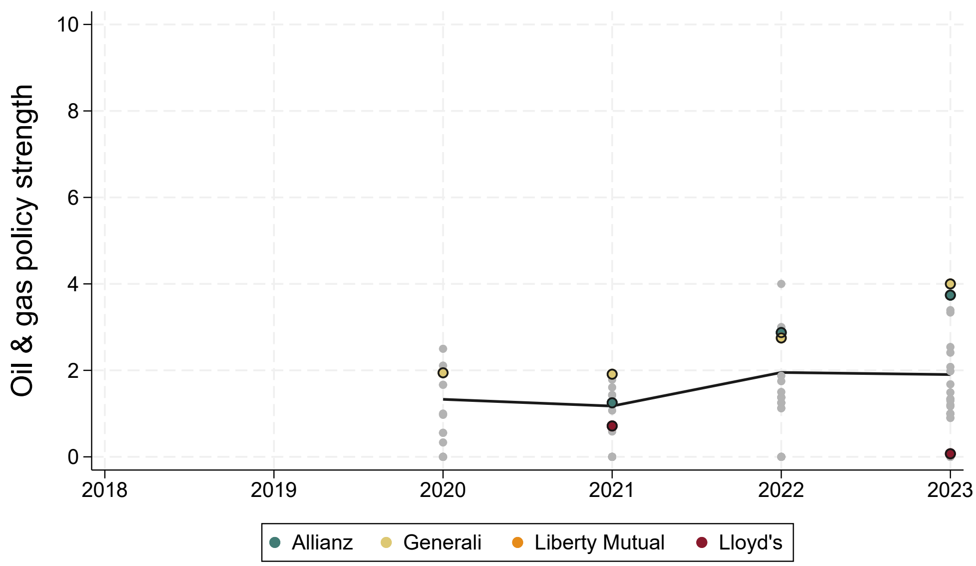
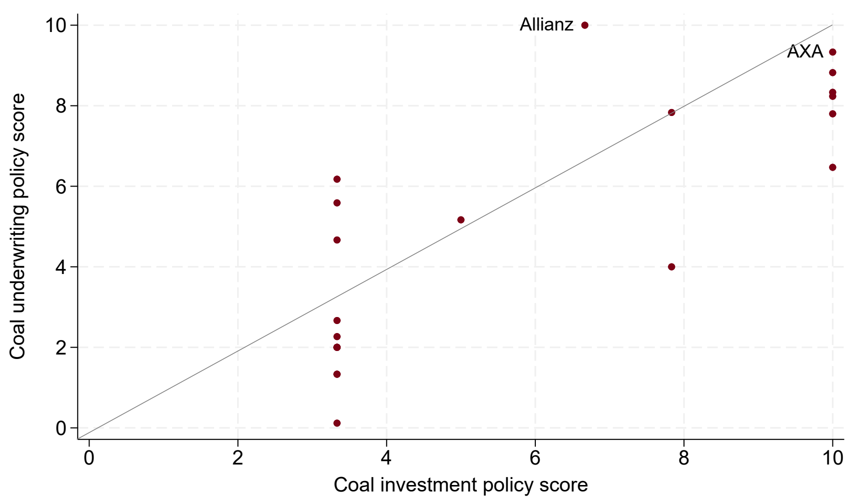


Figure OA.3: Alignment of carbon underwriting and investment policy stringency

The figure shows the relationship between the stringency of carbon underwriting and carbon investment policies for the year sample 2023. Each dot represents the combination of underwriting and investment policies of an insurer. Panel A shows the relationship for coal policies, while Panel B shows the relationship for oil & gas policies. The sample is based on annual scorecards compiled by Insure Our Future (IOF) and comprises 25 insurers with carbon policies in place.

Panel A: Coal underwriting policies



Panel B: Oil & gas underwriting policies

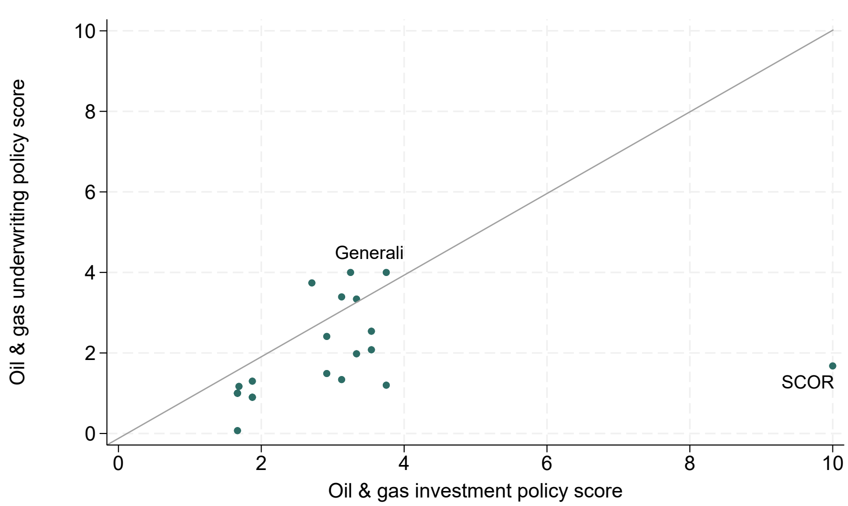


Figure OA.4: Certificate of Liability Insurance of Black Butte Coal Mine

The figure shows the Certificate of Liability Insurance of Black Butte Coal Mine dated September 26, 2018, on a standardized ACORD 25 form filed with the Wyoming Department of Environmental Quality.

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ACORD® **CERTIFICATE OF LIABILITY INSURANCE**

DATE (MM/DD/YYYY) 09/26/2018

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must have ADDITIONAL INSURED provisions or be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

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CONTACT NAME:
PHONE (A/C, No, Ext): 1-877-945-7378 FAX (A/C, No): 1-888-467-2378
E-MAIL ADDRESS: certificates@willis.com

INSURER(S) AFFORDING COVERAGE	NAIC #
INSURER A : American Guarantee and Liability Insurance	26247
INSURER B : Zurich American Insurance Company	16535
INSURER C : ACE Property & Casualty Insurance Company	20699
INSURER D :	
INSURER E :	
INSURER F :	

INSURED
Black Butte Coal Company
101 Black Buttes Road
Point Of Rocks, WY 82942 USA

COVERAGES CERTIFICATE NUMBER: W8113289 REVISION NUMBER:

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSD	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
A	X COMMERCIAL GENERAL LIABILITY; CLAIMS-MADE, X OCCUR; GEN'L AGGREGATE LIMIT APPLIES PER: X POLICY, PRO-JECT, LOC; OTHER:			GLO 5851797-06	10/01/2018	10/01/2019	EACH OCCURRENCE	$ 1,000,000
							DAMAGE TO RENTED PREMISES (Ea occurrence)	$ 1,000,000
							MED EXP (Any one person)	$ 10,000
							PERSONAL & ADV INJURY	$ 1,000,000
							GENERAL AGGREGATE	$ 2,000,000
							PRODUCTS - COMP/OP AGG	$ 2,000,000
								$
B	AUTOMOBILE LIABILITY; X ANY AUTO; OWNED AUTOS ONLY; SCHEDULED AUTOS; HIRED AUTOS ONLY; NON-OWNED AUTOS ONLY			BAP 5851796-06	10/01/2018	10/01/2019	COMBINED SINGLE LIMIT (Ea accident)	$ 1,000,000
							BODILY INJURY (Per person)	$
							BODILY INJURY (Per accident)	$
							PROPERTY DAMAGE (Per accident)	$
								$
C	X UMBRELLA LIAB, X OCCUR; EXCESS LIAB, CLAIMS-MADE; DED, X RETENTION $ 10,000			G2790869A 004	10/01/2018	10/01/2019	EACH OCCURRENCE	$ 5,000,000
							AGGREGATE	$ 5,000,000
								$
	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY Y/N; ANYPROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBEREXCLUDED? (Mandatory in NH); If yes, describe under DESCRIPTION OF OPERATIONS below	N/A					PER STATUTE / OTH-ER	
							E.L. EACH ACCIDENT	$
							E.L. DISEASE - EA EMPLOYEE	$
							E.L. DISEASE - POLICY LIMIT	$

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (ACORD 101, Additional Remarks Schedule, may be attached if more space is required)
Re: Black Butte Coal Co. Permit #467 and all subsequent renewals.

05-14-2019
PT0467

CERTIFICATE HOLDER
Wyoming Dept. of Environmental Quality
200 West 17th Street
Cheyenne, WY 82002

CANCELLATION
SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE
Rachel Harwood

ACORD 25 (2016/03) The ACORD name and logo are registered marks of ACORD

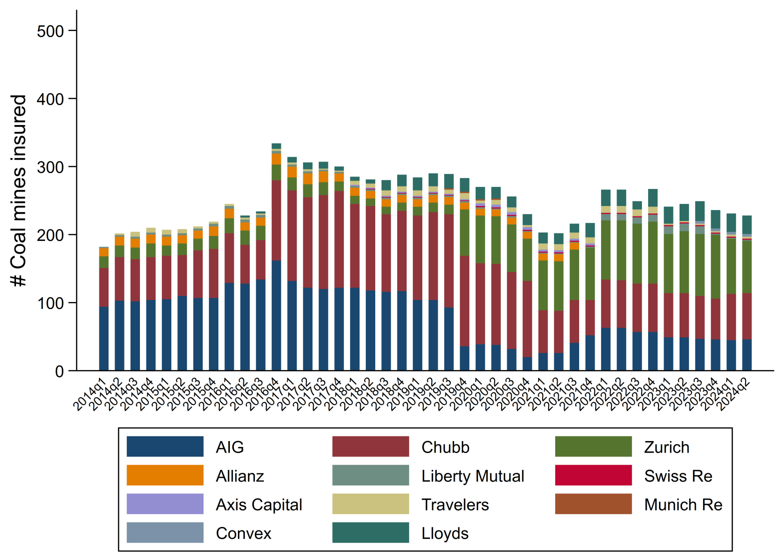
SR ID: 16780344 BATCH: 882111

TFN6 6/339
RECD OCT 10, 2018

Figure OA.5: Number of insured coal mines over time

The figure displays the number of insured coal mines over time. For each insurer-quarter, we count the number of unique mines insured by that insurer. Panel A presents this information for insurers that adopted a coal underwriting policy at any point during the sample period, while Panel B presents this information for those that never did. The sample includes all coal mines listed in MSHA's Mine Data Retrieval System between 2014Q1 and 2024Q2, provided they report at least one quarter of non-zero coal production, and for which we successfully obtained Certificates of Liability Insurance of ACORD 25 forms from state-level agencies. Table A.1 provides descriptions of all variables.

Panel A: Insurer with a coal underwriting policy



Panel B: Insurers without a coal underwriting policy

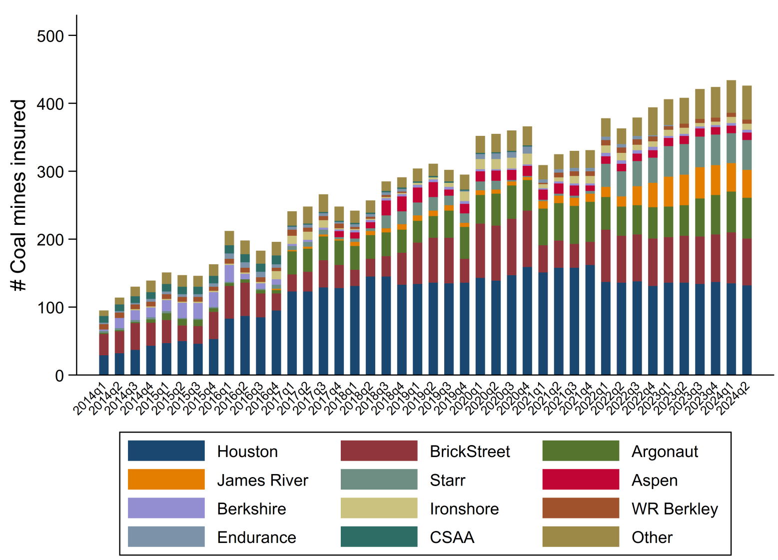
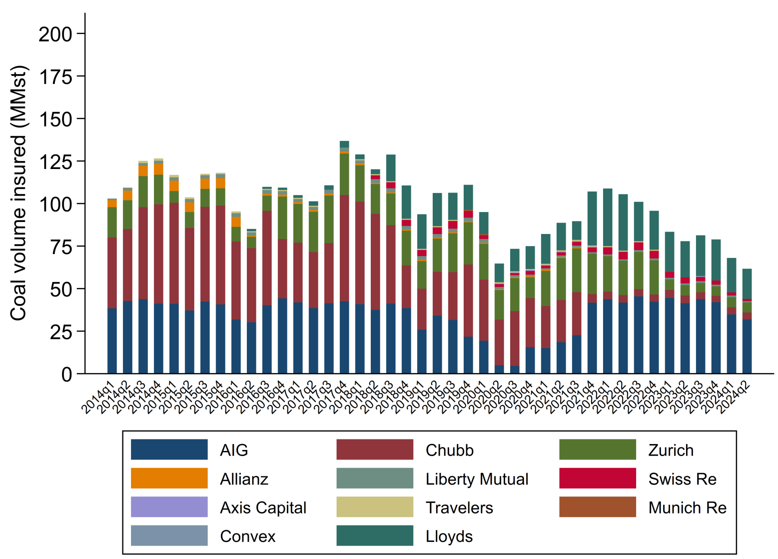


Figure OA.6: Volume of coal insured over time

The figure displays the volume of coal insured over time. For each insurer-quarter, we aggregate coal production across all mines insured by that insurer. Panel A presents this information for insurers that adopted a coal underwriting policy at any point during the sample period, while Panel B presents this information for those that never did. The sample includes all coal mines listed in MSHA's Mine Data Retrieval System between 2014Q1 and 2024Q2, provided they report at least one quarter of non-zero coal production, and for which we successfully obtained Certificates of Liability Insurance of ACORD 25 forms from state-level agencies. Table A.1 provides descriptions of all variables.

Panel A: Insurer with a coal underwriting policy



Panel B: Insurers without a coal underwriting policy

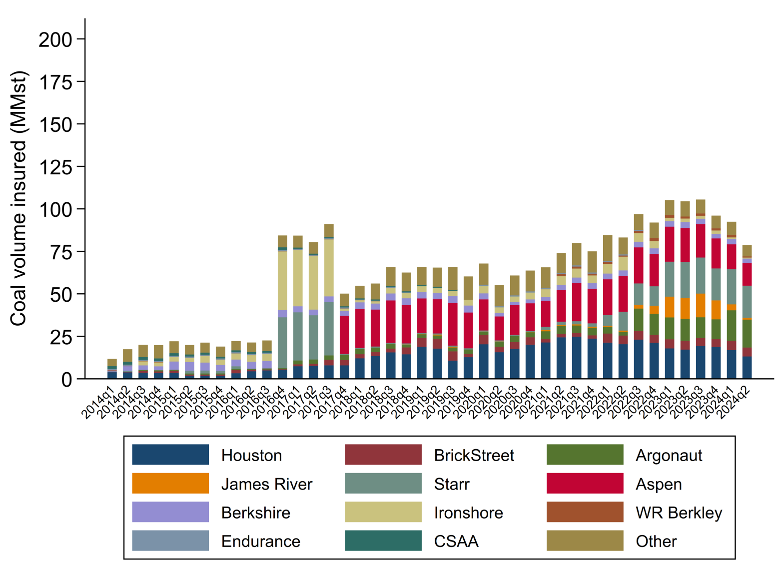


Figure OA.7: Coal mines' insurance status and underwriting policies by insurance line

This figure displays 90% confidence intervals and coefficient estimates from the following OLS regression:

$$Inactive\ insurance_{s,m,l,i,t} = \sum_{t=-6}^{t=6} \beta_t \times Coal\ policy_i \times Event\ quarter_{s,t} + \alpha_{s,m,l,i} + \alpha_{s,m,t} + \epsilon_{s,m,l,i,t},$$

where s indexes a stack, m a mine, l an insurance line, i an insurer, and t a quarter. The dependent variable, *Inactive insurance*, equals one if an insurer does not insure a mine in a given quarter, and zero if it does. *Coal policy* equals one for mines insured by an insurer adopting a coal underwriting policy, and zero otherwise. $\alpha_{s,m,l,i}$ are stack-mine-insurance line-insurer fixed effects, while $\alpha_{s,m,t}$ are stack-mine-time fixed effects. The initial sample of mines includes all coal mines listed in MSHA's Mine Data Retrieval System between 2014Q1 and 2024Q2, provided they report at least one quarter of non-zero coal production, and for which we successfully obtained Certificates of Liability Insurance on ACORD 25 forms from state-level agencies. For each insurer that adopts a coal underwriting policy, we identify all mines it insures and construct a balanced sample of 13 quarterly observations per mine-insurance line-insurance triplet, six before and six after the policy adoption quarter, whenever information on the liability insurance certificates of a given mine is available. These mine-insurance line-insurance triplets form the treated observations in the stack. As control observations, we include all other mine-insurance line-insurance triplets that include the same mines but insurers that never adopt a coal underwriting policy. Standard errors are clustered at the insurance group-insurance line-stack level. Table A.1 provides descriptions of all variables.

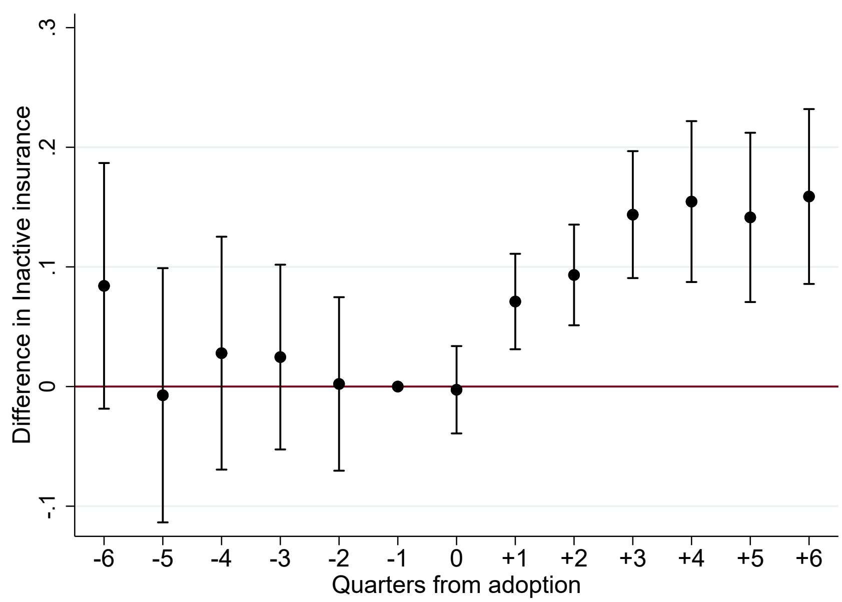
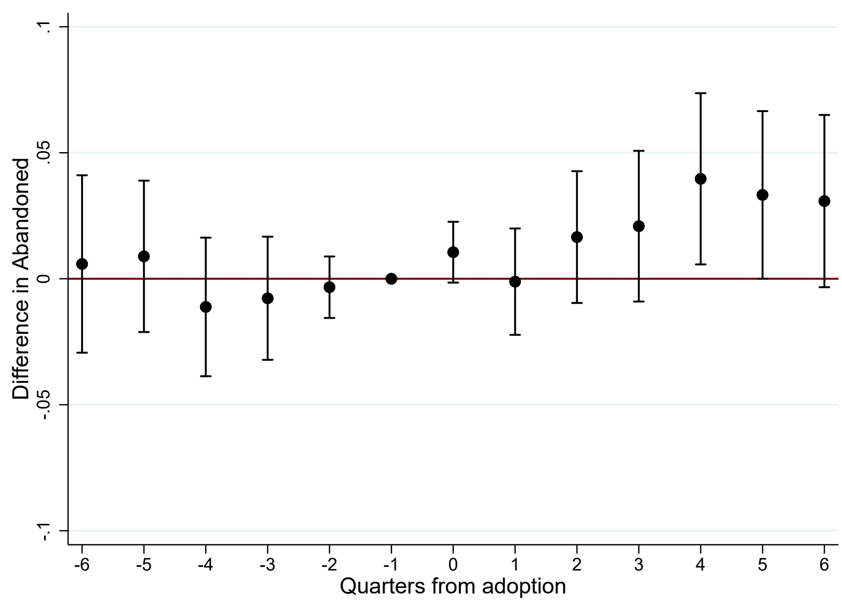


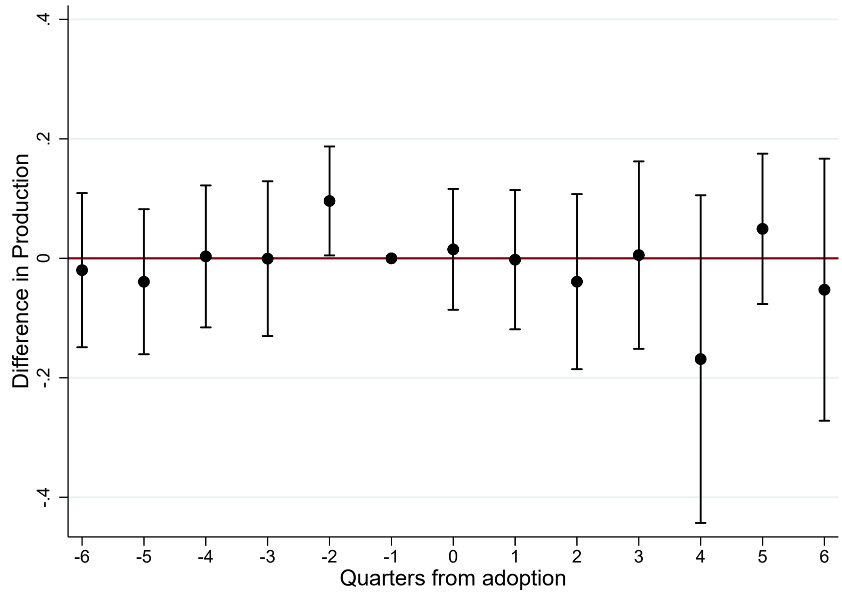
Figure OA.8: Coal mine outcomes and underwriting policies

This figure reports dynamic treatment effect estimates with 90% confidence intervals computed using the cohort-aggregated event-study estimator of de Chaisemartin and d'Haultfœuuille (2026), implemented via `did_multiplegt_dyn` as described in de Chaisemartin et al. (2025). We apply the estimator without modification. Event time is measured in quarters relative to the insurer's coal-policy adoption ($t = 0$); if a mine is exposed to multiple adoptions, the first defines treatment. A mine is *coal-policy exposed* if, between 2014 and 2016, it maintained an insurance relationship lasting at least eight quarters with an insurer that subsequently adopted a coal underwriting policy. The dependent variable is a dummy for mine abandonment (Panel A), the volume of coal produced (Panel B), or the average number of employees (Panel C). The sample comprises all mines underlying the analyses reported in Table 4; Panels B and C further restrict to mines active throughout the full period. Standard errors are clustered at the mine level. See Table A.1 for variable definitions.

Panel A: Abandoned



Panel B: Production



Panel C: # Employees

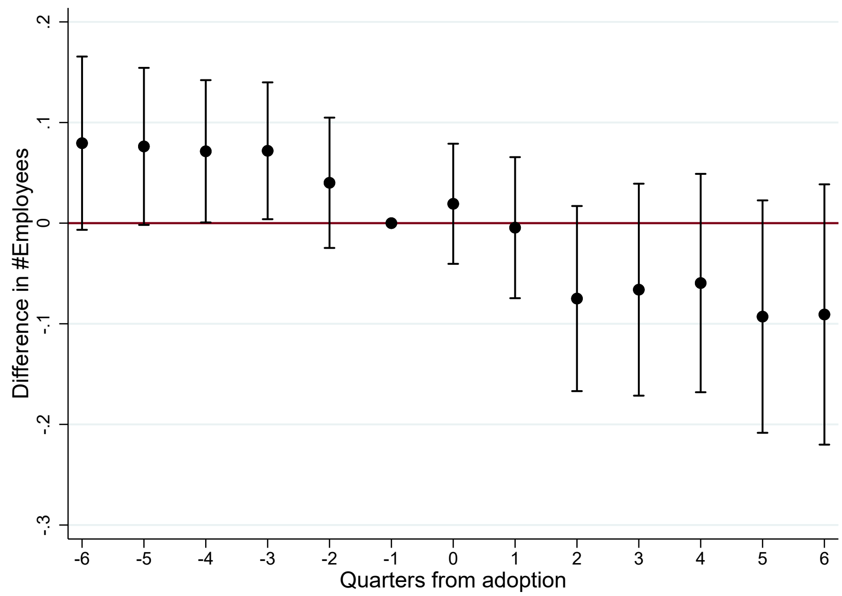


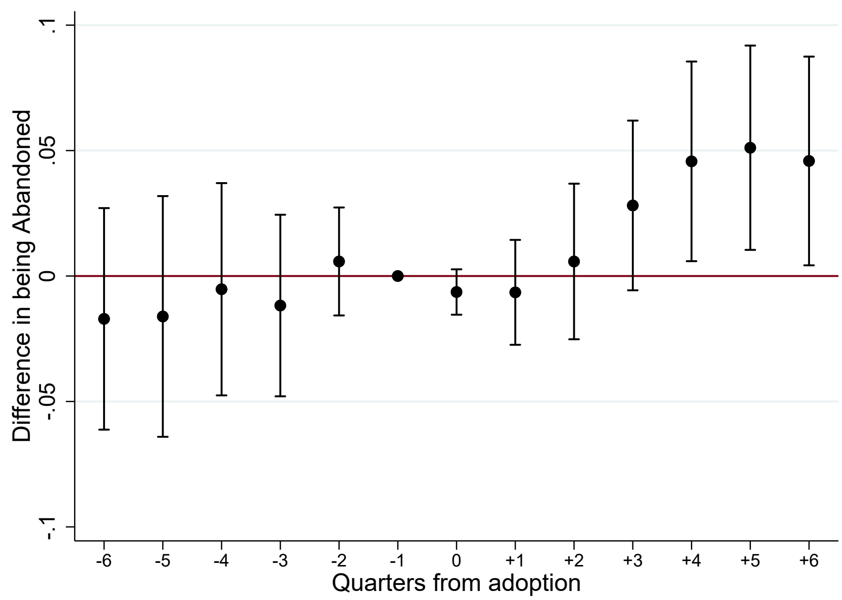
Figure OA.9: Coal mine outcomes and underwriting policies

This figure displays coefficient estimates and 90% confidence intervals from the following OLS regression:

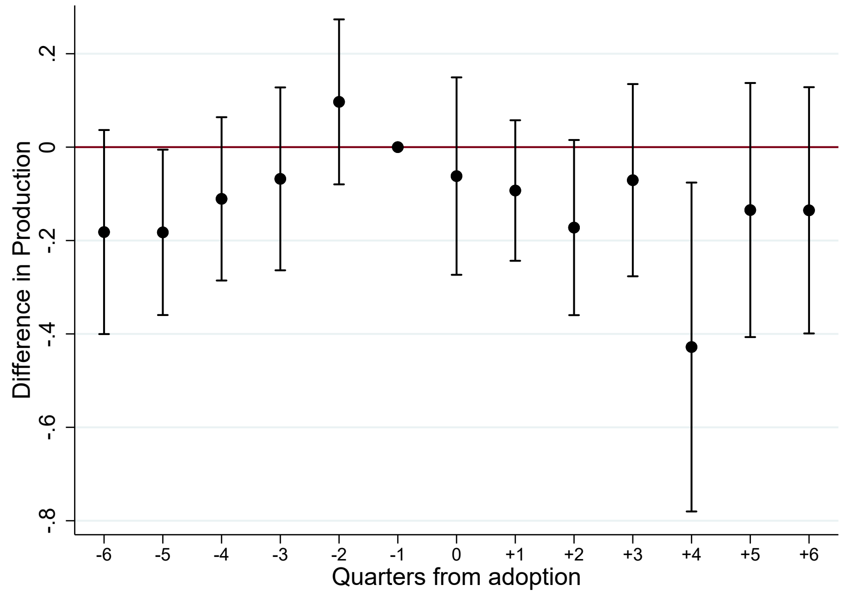
$$Coal\ mine\ outcome_{s,m,t} = \sum_{t=-6}^{t=6} \beta_t \times Coal\ policy\ exposed_{s,m} \times Event\ quarter_{s,t}\ + \alpha_{s,m} + \alpha_{s,t} + \epsilon_{s,m,t},$$

where s indexes a stack, m a mine, and t a quarter. The dependent variable, *Coal mine outcome*, is a dummy variable indicating whether a mine is abandoned (Panel A), the volume of coal produced (Panel B), or the average number of employees (Panel C). *Coal policy exposed* equals one for mines that, between 2014 and 2016, have a relationship lasting at least eight quarters with at least one insurer that subsequently adopted a coal underwriting policy. *Event quarter* are dummy variables indicating quarters relative to policy adoption. If a mine is exposed to multiple such adoptions, only the first instance is used to define treatment. The sample includes all mines from Table 4, provided that we successfully obtained Certificates of Liability Insurance on ACORD 25 forms from state-level agencies between 2014 and 2016. In Panels B and C, the sample includes only mines that are active throughout the entire sample period. Standard errors are clustered at the mine-stack level. Table A.1 provides descriptions of all variables.

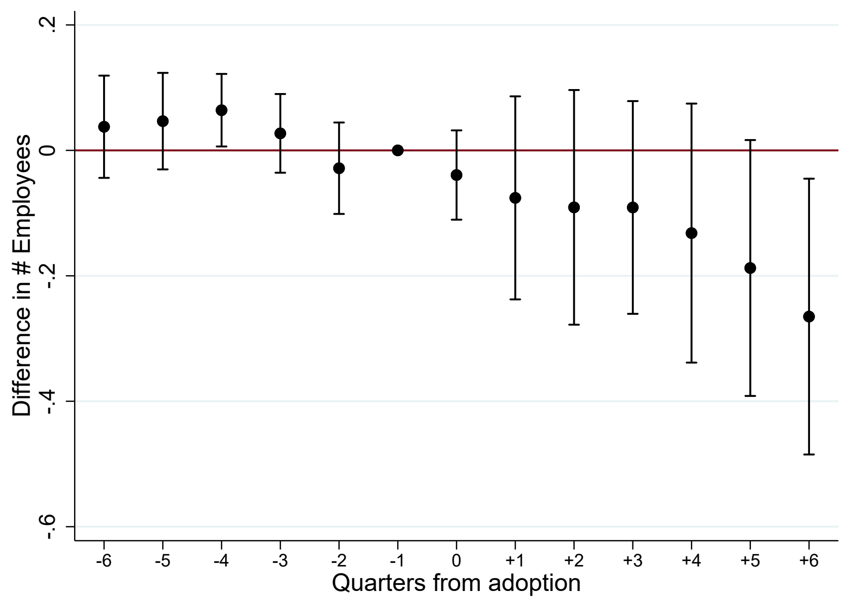
Panel A: Abandoned



Panel B: Production



Panel C: # Employees



B.2 Additional Tables

Table OA.1: Assessment of carbon underwriting policies

This table reports the five dimensions over which carbon underwriting policies are assessed by IOF and the respective description.

IOF scoring dimension	Description
Scope	Does a carbon underwriting policy rule out insurance for (i) all types of new coal infrastructure (including mines and power plants as well as transport facilities); (ii) extreme fossil fuels such as tar sands, associated pipelines, Arctic and ultra-deepwater drilling; and (iii) any oil and gas expansion projects that drive increased production?
Types of cover	Does a carbon underwriting policy apply to all lines of business for new and existing projects and companies, except cover for protecting workers, ringfenced renewable energy projects, and existing mine reclamation surety bonds?
	Does a carbon underwriting policy of a reinsurer apply to treaty as well as facultative reinsurance?
Fossil fuel companies	Does a carbon underwriting policy apply comprehensive criteria to define companies operating in coal, oil and gas, and tighten cover over time in line with the need to phase out these fossil fuels completely?
	Does a carbon underwriting policy immediately exclude new customers from the fossil fuel sector not aligned with a 1.5°C pathway and phase out all insurance services within two years for existing fossil fuel company customers not aligned with such a pathway?
Emissions reduction targets	Does an insurer set emissions reduction targets for new projects as well as ongoing operations which they insure, and define short- and medium-term targets across their entire commercial property & casualty portfolio?
	Do the targets cover the Scope 3 emissions of all carbon-intensive sectors, including energy and power, and aim for a reduction of insured emissions of at least 43% by 2030, in line with IPCC findings?
Human rights	Does a carbon underwriting policy include robust due diligence to ensure that clients fully respect all human rights, including a requirement that they obtain and document the Free, Prior, and Informed Consent of impacted Indigenous Peoples?

Table OA.2: Insurer characteristics

This table reports insurance characteristics for all insurers in IOF's scorecard. *Adoption date* is constructed via manual online news searches of each insurer's earliest coal underwriting policy adoption date. For XL Catlin, the variable refers to the period prior to its acquisition by AXA. *Unlisted insurer* and *Specialty insurer* are header variables. While *NZIA* is time-varying, this table only reports the maximum value per insurer.

Name	Adoption date	Region (Country)	Unlisted insurer	Specialty insurer	NZIA
AIG	01-03-2022	U.S. (United States)	0	0	0
AXA	12-12-2017	Europe (France)	0	0	1
Allianz	04-05-2018	Europe (Germany)	0	0	1
Aviva	N/A (unknown adoption date)	Europe (United Kingdom)	0	0	1
Axis Capital	16-10-2019	RoW (Bermuda)	0	1	0
Berkshire Hathaway	No policy adoption	U.S. (United States)	0	0	0
Chubb	01-07-2019	U.S. (United States)	0	0	0
Convex	01-02-2022	RoW (Bermuda)	1	1	0
Everest Re	No policy adoption	RoW (Bermuda)	0	1	0
FM Global	No policy adoption	U.S. (United States)	1	1	0
Generali	21-02-2018	Europe (Italy)	0	0	1
HDI	18-04-2019	Europe (Germany)	1	0	0
Hannover Re	18-04-2019	Europe (Germany)	0	1	1
Legal and General	No policy adoption	Europe (United Kingdom)	0	0	0
Liberty Mutual	13-12-2019	U.S. (United States)	1	0	0
Lloyd's	16-12-2020	Europe (United Kingdom)	1	1	1
MS&AD	30-09-2020	Asia (Japan)	0	0	0
Mapfre	11-03-2019	Europe (Spain)	0	0	1
MetLife	No policy adoption	US (United States)	0	0	0
Munich Re	06-08-2018	Europe (Germany)	0	0	1
PICC	No policy adoption	Asia (China)	0	0	0
Ping An	N/A (unknown adoption date)	Asia (China)	0	0	0
Prudential	No policy adoption	U.S. (United States)	0	0	0
QBE	01-04-2019	RoW (Australia)	0	0	1
SCOR	06-09-2017	Europe (France)	0	1	1
Samsung FM	12-11-2020	Asia (Korea, Rep.)	0	0	0
Sinosure	No policy adoption	Asia (China)	1	0	0
Sompo	23-09-2020	Asia (Japan)	0	0	1
Starr	No policy adoption	U.S. (United States)	1	1	0
Swiss Re	02-07-2018	Europe (Switzerland)	0	0	1
TIAA	No policy adoption	U.S. (United States)	1	0	0
The Hartford	20-12-2019	U.S. (United States)	0	0	0
Tokio Marine	28-09-2020	Asia (Japan)	0	0	1
Travelers	07-02-2022	U.S. (United States)	0	0	0
WR Berkley	No policy adoption	U.S. (United States)	0	1	0
XL Catlin	No policy adoption	Europe (Ireland)	0	1	0
Zurich	13-11-2017	Europe (Switzerland)	0	0	1

Table OA.3: Correlations between carbon underwriting and investment policies

This table reports correlations between carbon underwriting and investment policies. In Panel A, the table reports the correlations between carbon underwriting policies and carbon investment policies. The sample comprises 32 insurers and spans the period from 2017 to 2023. In Panel B, the table reports the correlations between the scores assigned to carbon underwriting policies and carbon investment policies of insurers. The sample comprises 25 insurers with carbon policies in place and spans the period from 2018 to 2023.

Panel A: Prevalence of policies				
	Coal policy	*Oil & gas policy*	*Coal inv. policy*	*Oil & gas inv. policy*
Coal policy	1.00			
Oil & gas policy	0.62	1.00		
Coal investment policy	0.79	0.65	1.00	
Oil & gas investment policy	0.59	0.87	0.62	1.00
Panel B: Stringency of policies				
	Coal score	*Oil & gas score*	*Coal inv. score*	*Oil & gas inv. score*
Coal score	1.00			
Oil & gas score	0.55	1.00		
Coal investment score	0.81	0.34	1.00	
Oil & gas investment score	0.36	0.33	0.55	1.00

Table OA.4: Descriptive statistics on carbon underwriting policies

This table presents descriptive statistics on carbon underwriting policies. The sample is based on annual scorecards compiled by Insure Our Future (IOF). Table A.1 provides descriptions of all variables.

	Obs.	Mean	Std.	25th	Median	75th
Panel A: Insurer-year sample						
Coal policy	181	0.66				
Coal policy score	162	2.44	2.59	0.00	1.85	3.60
Oil & gas policy	117	0.55				
Oil & gas policy score	117	0.90	1.09	0.00	0.59	1.43
CCPI	181	47.82	15.81	37.39	52.20	60.85
NZIA	181	0.13				
Specialty insurer	181	0.23				
Unlisted insurer	181	0.15				
High fossil fuels GWP share	181	0.54				
Total assets (billion $)	180	299.98	350.52	61.31	148.14	437.56
ROA (%)	180	1.51	1.83	0.70	1.27	2.23
GWP (billion $)	130	44.98	32.17	20.00	37.48	63.68
Solvency ratio (%)	130	17.04	10.75	8.71	14.48	22.01
# RepRisk incidents	146	2.53	3.31	0.00	1.00	4.00
Panel B: Listed insurer sample						
CAR[0,1]	18	-0.53	1.91	-1.40	-0.42	-0.14

Table OA.5: Determinants of oil & gas underwriting policies

This table presents results from the following OLS regression:

$$Y_{i,t} = \beta \times X_{i,t-1} + \alpha_t + \epsilon_{i,t},$$

where i indexes an insurer and t a year. In Column 1, Y is *Oil & gas policy*, which equals one if the insurer has an oil & gas underwriting policy, and zero otherwise. In Column 2, Y is *Oil & gas policy score*, which is a score ranging from 0 to 10, with higher scores indicating stricter oil & gas underwriting policies. X is a vector of insurer-level characteristics. The sample is based on annual scorecards compiled by Insure Our Future (IOF); Column 2 additionally conditions on insurers with a policy in place. Standard errors are clustered at the insurer level and reported in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. Table A.1 provides descriptions of all variables.

	Oil & gas policy	*Oil & gas policy score*
	(1)	(2)
CCPI	0.010**	0.029***
	(0.005)	(0.008)
NZIA	0.275*	0.406
	(0.136)	(0.265)
Specialty insurer	-0.270	-0.823*
	(0.195)	(0.444)
Unlisted insurer	-0.392*	-1.088**
	(0.200)	(0.453)
High fossil fuel GWP share	-0.212	-0.631**
	(0.162)	(0.236)
Total Assets (log)	-0.049	0.015
	(0.073)	(0.105)
ROA	-0.009	-0.059
	(0.023)	(0.084)
Time FE	Yes	Yes
Obs.	117	64
Adj. R^2	0.312	0.452
# Insurers in sample	31	22

Table OA.6: Coal mine outcomes and share of underwriters with policies

This table presents results from the following OLS regression estimated at the mine-quarter level:

$$Coal\ mine\ outcome_{m,t} = \beta \times Share\ coal\ policy\ exposed_{m,t} + \alpha_m + \alpha_t + \epsilon_{m,t}$$

where m indexes a mine and t a quarter. The dependent variable, *Coal mine outcome*, is a dummy variable indicating whether a mine is abandoned (Column 1), the volume of coal produced (Column 2), or the average number of employees (Column 3). *Share coal policy exposed* is defined as $\sum_i w_{m,i} Post\ coal\ policy_{i,t}$ where i indexes an insurer, w are equal weights allocated to each insurer with at least eight quarters of active insurance relationship with a given mine between 2014 and 2016, and *Post coal policy* equals one for insurer-quarters after a coal underwriting policy is introduced, and zero otherwise. The sample includes all mines from Table 4, excluding those that do not have an active insurance relationship with the same insurer for at least eight quarters between 2014 and 2016. In Columns 2 and 3, the sample includes only mines that are active throughout the entire sample period. Standard errors are clustered at the mine level and reported in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. Table A.1 provides descriptions of all variables.

	Abandoned	*Production (log)*	*# Employees (log)*
	(1)	(2)	(3)
Share coal policy exposed	0.047	-0.220**	-0.207**
	(0.037)	(0.094)	(0.100)
Coal mine FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Obs.	7,342	1,559	1,595
Adj. R^2	0.577	0.896	0.894
# Coal mines	175	38	38

about ECGI

The European Corporate Governance Institute has been established to improve *corporate governance through fostering independent scientific research and related activities.*

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The views expressed in this working paper are those of the authors, not those of the ECGI or its members.

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