Transition, Hedge, or Resist? Understanding Political and Economic Behavior toward Decarbonization in the Oil and Gas Industry

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Abstract

Many oil and gas firms claim they are going green. But are they actually walking the talk? We analyze the political and economic behavior of publicly traded oil majors to understand the degree to which they are decarbonizing. We collect a wide range of firm-level data from 2004 to 2019, including a novel measurement of political behavior based on original coding of corporate earnings calls. Our analysis yields four main findings. First, firms' political and economic behavior are not necessarily correlated, demonstrating the value of a two-pronged political economy approach to the study of multinational firms. Second, not a single firm is shifting away from fossil fuels during the time frame studied. Changes in business behavior have been relatively modest in scope. The most ambitious firms are engaging in hedging – mitigating risk through diversification rather than moving toward decarbonization. Third, major oil and gas firms meliorate anti-climate political positions between 2010 and 2018. Finally, firms with greater progress towards decarbonization tend to be located in or sell their products in jurisdictions with more stringent environmental regulation, have smaller refining sectors, and be involved in more industry coalitions.

Key words

Climate change, fossil fuels, decarbonization, firms, lobbying, business politics

Word count: 11,965 (including abstract, footnotes, and references)

Introduction

Decarbonizing the economy requires overcoming the incentive of fossil-fuel dependent industries to maintain the status quo. This includes industrial, transport, and agricultural sectors, power producers, and fossil fuel companies. Firms in these sectors tend to be amongst the most powerful interest groups in many polities, and correspondingly, strong opponents to ambitious climate policies.

As one of the largest and most important industries in the world economy, oil and gas firms occupy a structural position of power. Other industries and consumers also depend on their products. Moreover, unlike sectors for which fossil fuels are merely an input, the oil and gas business model is defined by fossil fuel production. This creates a potential existential crisis as the industry confronts climate change, creating a strong incentive to resist decarbonization (Colgan et al., 2021). Yet, simultaneously, many oil and gas firms aim to become "net zero," or even to transition entirely away from their core business of fossil fuel extraction. Under what conditions should we expect oil and gas firms to resist decarbonization, and what might make them seek to transition to a carbon-free future?

We examine this question by conceptualizing firms as both political and economic actors, and by empirically evaluating their approaches to decarbonization in the last two decades along these two dimensions. This approach contributes an analytic framework and empirical baseline to help observers assess future prospects for transition.

As economic actors, oil and gas firms' activities are primary sources of greenhouse gases (GHGs). Recent analysis of historical emissions suggests that 63% of the global carbon dioxide and methane emitted can be traced to a mere 90 oil and gas firms (Ekwurzel et al., 2017; Heede, 2014). These "carbon majors" possess fossil fuel reserves that can generate significant profits for investors but will also intensify climate change. Here we focus on a subset of these actors: the top ten publicly traded oil and gas companies.[1]

As political actors, oil and gas firms have been amongst the most influential interest groups in the politics of many nations. According to one NGO report, the five largest oil majors have spent $200 million per year lobbying against climate policy since the Paris Agreement, and about the same amount annually on climate-related branding and public relations (Influence Map, 2019). Yet simultaneously, some companies assert that they can and must play a major role in addressing climate change (Halstead, 2020).

Our inquiry seeks to understand empirically the extent to which privately-owned oil majors are contributing to decarbonization through changes in economic and political behavior. Guided by our two-dimensional framework, we collect a range of firm-level data from 2004 to 2019, including a novel measurement of political behavior based on original coding of corporate earnings calls.

[1] Significantly state-owned or controlled national oil companies (NOCs), are also critical in understanding decarbonization, since they account for 43 percent of global capital expenditures in oil and gas. Excluding Equinor, we focus solely on investor-owned entities due to data limitations, heterogeneous measurement, and differing political pressures facing NOCs. See Heede 2014, Mahdavi 2020, Manley and Heller 2020.28/05/2021 17:33:00

We inductively address three research questions. First, how has the behavior of the oil and gas sector changed over time? Second, to what extent do firms vary in their business and political behavior vis-a-vis decarbonization? And third, what might explain this variation? While we do not provide a dispositive answer to this third question, we probe the plausibility of different explanations by identifying correlates of decarbonization behavior via statistical analysis. This helps identify relationships that could guide future research.

There are three main findings. First, we do not find any evidence of meaningful decarbonization efforts among the top 10 oil and gas firms (oil majors). In terms of our framework, the most ambitious firms are engaging in *hedging* – mitigating risk through diversification rather than moving toward wholesale decarbonization. Second, generally speaking, oil majors have adopted more pro-climate political behavior since 2010. In particular, many firms have increased their acceptance of climate science, carbon pricing and international cooperation. Third, we observe that firms that engage in hedging tend to be located in or sell their products in jurisdictions with more stringent environmental regulation, have smaller refining capacity, and be involved in more industry coalitions.

These findings contribute to existing literature in several ways. First, they build on a growing political economy literature that treats firms as political actors making distinct political and ecological choices (Meckling 2015; Prakash, 2000; Pulver, 2002). Much of the existing literature examines either the political or business behavior of firms separately; this is especially true of oil and gas companies (Caldecott et al 2018; Chaudhry and Law 2018; Dietz et al 2018; Fletcher et al 2018; Nasiritousi 2017; Pickl 2019). Our approach demonstrates the value of considering these dimensions in tandem to develop a holistic view of firm behavior. Importantly, we find that these dimensions are not necessarily correlated – demonstrating that firms are not monolithic. Disaggregating political and economic behavior is a lesson that can be applied to other issues in world politics. Second, we develop a novel method for examining firms' political behavior by coding their statements in quarterly earnings calls (Mahdavi et al, 2021). This method could be applied to any publicly listed firms of political significance. Third, we provide the most comprehensive view of oil majors' transition—or lack thereof—to date, a sobering empirical contribution to debates on the political economy of climate change (Paterson, 2020).

Though we examine the oil and gas sector, our analytic framework could be applied to other hard-to-abate sectors as well. That said, we expect that our findings are less applicable to national oil companies with high degrees of state ownership, whose decisions may follow distinct logics (Victor et al. 2011). We consider the generalizability of the argument in the conclusion.

1. Navigating the Decarbonization Dilemma

Firms are under growing pressure from investors, activists, and regulators to address the contributions to climate change. And yet, climate policy can pose an existential threat to a firm that has built its entire asset portfolio, personnel, infrastructure, and reputation around fossil fuels. Potential responses to these conflicting pressures range from business as usual to complete

transition to fossil-free energy production. This section explores the dimensions of this decarbonization dilemma in greater detail.

Climate Change as an Existential Problem

Achieving substantial action on climate mitigation will require reducing fossil fuel consumption. It is therefore unsurprising that oil and gas firms oppose climate regulations. The NGO InfluenceMap shows that since the Paris Agreement was concluded in 2015, five oil and gas firms – Exxon, Shell, Chevron, BP and Total – have spent over US $1 *billion* in climate-related branding and lobbying (InfluenceMap 2019). Similarly, Brulle estimates sectors affected by proposed climate legislation spent over $2 billion lobbying the US Congress between 2000-2016 (Brulle, 2018). These data are consistent with political economy approaches that highlight how firms advocate for policies that advance their commercial interests (Keohane & Milner, 1996).

Serious decarbonization poses an existential threat to these firms: fundamentally, they must change their business model (i.e. no longer be "oil and gas" firms) or fold. As these threats materialize, existing research posits that firms will fight harder to preserve the status quo – and the rents they extract from it (Colgan et al. 2021). Similarly, Breetz et al. (2018) demonstrate that political opposition to clean technology increases as it moves from development to deployment. When new technologies are in their nascent stages, incumbents' opposition is minimal. However, as these technologies are more widely deployed, incumbents fight harder, since the prospect of large losses becomes both considerable and immediate. This pattern is evident in the electricity sector, as renewables become a cost-effective replacement for fossil-based power (Breetz et al., 2018). Similarly, oil and gas firms may fight harder as fuel alternatives become more appealing. However, the simple observation that firms will resist decarbonization policies tells us little about variation across firms in the same industry, or how the same firm might vary over time.

Growing External Pressure

During the time frame of our study, oil and gas firms have faced growing external pressure to decarbonize. Three notable changes in the broader political opportunity structure may affect their decision-making. Variation in these pressures, both across firms and time, may help to explain why oil and gas companies adopt different approaches.

First, domestic environmental standards tightened in many jurisdictions. For example, nearly all oil-producing countries have now implemented policies to regulate or eliminate methane flaring (Elvidge et al. 2018). More dangerously, some major markets are promoting rapid adoption of electric vehicles and other technologies that could substantially reduce demand for oil and gas. And a growing number of countries and subnational jurisdictions have now set net zero targets (Energy and Climate Intelligence Unit 2019), furthering pressure for decarbonization.

Second, in parallel to the 2015 Paris Agreement, firms took voluntary action to demonstrate alignment with global climate goals—though these varied significantly in robustness (Hale 2016). This rise of corporate climate targets provided ample leeway for emissions intensive

industries, including oil and gas, to define their own commitments, while also pressuring these actors to contribute in some way.

Third, firms faced growing pressure from activists and stakeholders to address their negative climate effects (e.g., Gupta et al. 2020; Nasiritousi 2017, 638). A spate of recent lawsuits has targeted fossil fuel companies and governments for failing to protect citizens from climate change – either through deliberate action or indifference. Increasing pipeline activism aims to frustrate development of more fossil infrastructure. The divestment campaign seeks to starve fossil fuel companies of much-needed capital. And shareholder activism has grown. We find a marked increase in the number of climate-related shareholder resolutions among the oil majors. Using data collected by EthVest, we coded the number of shareholder resolutions related to climate change from 1993-2019 to find that fully 43% of the resolutions were tabled in the last 5 years of the sample.

Reliance on Voluntary Governance

These trends are consistent with a considerable body of literature on corporate social responsibility (CSR) which suggests that firms can "do well by doing good:" curbing negative externalities such as environmental degradation or unsafe labor conditions can also improve a firm's bottom line. CSR underpins numerous voluntary initiatives, such as the United Nations Global Compact, the Forest Stewardship Council, or, in climate change, the Science-based Targets Initiative. The CSR literature provides a nuanced analysis of whether firms' self-regulation can be an effective change agent (Cashore et al., 2004; Garcia-Johnson, 2000; Green, 2014; Prakash, 2000; Prakash & Potoski, 2006; Van der Ven, 2019). In particular, Locke notes that "private power" – i.e. industry- and firm-based regulations and codes of conduct – can be effective when paired with the regulatory power of the state (2013). Studies of private regulation by third parties, such as the Forest Stewardship Council (FSC) or the Marine Stewardship Council, indicate that firms *may* change their practices, but only under a limited set of conditions. For example, the FSC has been almost universally adopted by timber producers in the Canadian province of British Columbia, but this is due to several converging factors – including dependence on foreign markets, a highly concentrated sector, and a persistent public perception of a forestry "problem" (Cashore et al., 2004). Research on the Marine Stewardship Council suggests that uptake has been widespread in the developed world, but limited in the developing world, where there are large and lucrative fish markets (Gulbrandsen, 2009).

In the climate arena, short-term voluntary action can have inconclusive or even negative effects on long-term decarbonization. The U.S. Carbon Pricing Leadership Coalition (CPLC) demonstrates this difficulty. The CPLC describes itself as a "voluntary initiative that catalyzes action towards the successful implementation of carbon pricing around the world" by convening governments, firms and civil society to share their experiences in pricing carbon.[2] The initiative lists a number of major oil and gas firms as partners, including Shell, Equinor, BP, ENI and Total. As Vormedal et al. demonstrate, oil majors have backed carbon pricing for two instrumental reasons. First, oil majors with a seat at the table can more readily influence outcomes. Second, carbon pricing is a means to ensure the continued competitiveness of natural gas. They note, "To the extent that carbon pricing triggers widespread coal-to-gas

[2] https://www.carbonpricingleadership.org/

switching…it supports the realization of a "gray" transition toward a lower-carbon future, in which Big Gas can expand its market shares at the expense of coal and become a major bridge fuel next to renewables" (2020, p. 144). Thus, oil majors' increasing acceptance of carbon pricing seems beneficial to the bottom line, while simultaneously slowing decarbonization efforts by locking in gas.

A Potential for Transformative Action?

As the previous example illustrates, measuring immediate reductions in GHG emissions are but one way to evaluate firms decarbonization efforts. For instance, van der Ven and colleagues note that "the challenge posed by decarbonization is bigger than pulling a set number of gigatons of CO2 equivalent out of the atmosphere" (van der Ven et al., 2016, p. 5). Rather, it involves disrupting "carbon lock-in" – the persistent market and policy failures that occur through interactions between "technological systems and governing institutions" (Unruh, 2000, p. 817). In this view, decarbonization requires understanding how economic, social and political systems produce market failures that constrain the adoption of carbon-friendly technologies (Seto et al., 2016; Unruh, 2000).

Have firms made efforts to transform in the oil and gas industry? Many have declared various kinds of "net zero" targets. One pathway for such a transformation might be that voluntary actions could lead to investments in decarbonization technologies that might scale and diffuse through market forces. The Oil and Gas Climate Initiative (OGCI) claims to have such a goal: OCGI is a voluntary initiative of 13 of the largest oil and gas firms, comprising 30% of global production.[3] Its aim is to "progress to net zero emissions in the second half of this century" by investing research and development funds in carbon capture and storage technologies.[4] Tellingly, the majority of its activities to date are aimed at reducing carbon emissions rather than switching to renewable energy. To be fair, if full decarbonization is the goal, it is reasonable to assume that dramatic results will not appear overnight. Optimists argue that structural changes are an important start, and indicate greater leadership in climate governance and enhance firms' capacity to undertake meaningful action in the future (Bach, 2019).[5]

2. Conceptualizing the political economy of decarbonization: firms as economic and political actors

The existential challenge of climate change for oil majors creates incentives to shift their business models; it also gives firms an increased interest in shaping the speed and direction of climate policies. Simultaneously, firms may have reasons to *appear* to be acting more aggressively than they actually are. In light of these tensions, we conceptualize our dependent variable, firm efforts toward decarbonization, in two dimensions: business behavior and political behavior. We argue that a full view of decarbonization requires considering both the *political* and *economic* strategies of firms. Our typology accounts for different strategic combinations.

[3] https://oilandgasclimateinitiative.com/our-members/#impact
[4] Ibid.
[5] This is consistent with Prakash 2000, that internal management practices are critical to greening firms.

Each dimension represents a continuum that runs from transition (moving away from fossil fuels) to resistance (maintaining a central role for fossil fuels in the economy). Here, we conceptualize a firm as "transitioning" if it makes efforts to incorporate non-fossil energy into its business model. We note that oil companies and some international organizations are still projecting a rise in demand for oil and gas, and, in common parlance, firms often refer to natural gas as a "transition fuel" (see Appendix A1). However, our measure of firm "transition" requires deeper action towards decarbonization – in light of the reality that a shift towards gas extraction and infrastructure may reduce emissions in the short-run but runs the risk of carbon lock-in (Seto et al. 2016).

Political behavior

We define political behavior as firm actions that have the objective or effect of shaping public policy or the policy preferences of other actors. Common examples include lobbying and public relations campaigns. It is a continuous variable that ranges from strong (i.e. costly) effort against pro-climate policies to strong (i.e. costly) effort supporting pro-climate policies. At the extreme anti-climate end, firms invest resources to combat any regulation that promotes decarbonization. At the extreme pro-climate end, firms publicly support policies that promote a transition, and invest resources to achieve this goal. In between these two end points are a continuum of weak anti-climate efforts and weak pro-climate efforts, which could include support for purely voluntary or less stringent policies.

Business behavior

We define business behavior as firms' profit-seeking activities in the market. These include producing and selling products, but also ancillary activities like research and development and market strategy. At the anti-climate extreme, firms continue "business as usual" (BAU): they make no efforts to reduce GHG emissions. At the pro-climate extreme, firms incur significant disruption by transforming their business model. They halt fossil fuel investments, and make all possible efforts to fully decarbonize. In between are firms that make minimal changes to BAU while others make non-trivial efforts to incorporate non-fossil energy into their business model.

A full description of the coding instrument for both dimensions is available in Appendix Tables A1 and A2.

Combining business and political behavior

There are four ideal-type strategies that firms can pursue along these two dimensions (Figure 1). We emphasize that these are ideal types, and that there will be a range of behaviors within each category. Broadly speaking, transitioners are firms whose political and business behavior push toward decarbonization, and do so relatively strongly compared to competitor firms. These leading firms are actively curbing their most carbon-intensive activities, pursuing new investments or implementing new business models. They seek to align the regulatory environment they and others face to match these goals. Conversely, resisters' political and business behavior both push against decarbonization and do so relatively strongly compared to

other firms. These firms aim to maximize short-term gains before regulatory measures require serious changes to their business behavior.

		POLITICAL BEHAVIOR	
		Pro-Climate	*Anti-Climate*
BUSINESS BEHAVIOR	*Pro-Climate*	Transitioner	Prepper
	Anti-Climate	Greenwasher	Resister

Figure 1: Ideal-type strategies for firms in sectors facing pressure to decarbonize

We note that "off equilibrium" ideal-type strategies are also possible. Preppers are those who choose relatively pro-climate business strategies in anticipation of changes to the regulatory environment. However, they choose not to also push for green policies, perhaps so that they can decarbonize at the pace and manner of their own choosing, instead of following regulatory requirements. Since they are motivated by future competition rather than public relations, their political behavior is perhaps not fully anti-climate, but less pro-climate than transitioners.

Greenwashers are those firms whose political behavior is more pro-climate than their business behavior. This strategy may suit firms who purposefully make political statements to deflect regulatory, consumer, or investor pressure and to cover for less-than-ambitious business behavior. For example, Total's failed 2009 campaign to rebrand itself as "contributing to the boom in new energies" quickly came apart when it was revealed the company had just abandoned all major wind projects and dedicated only 0.71% of overall investments to solar.[6]

Greenwashing could also capture those firms whose good-faith efforts simply lag behind their promises. Consider Repsol, which in 2019 became the first major to set a net-zero emissions goal. To meet this target, the company is devoting 25% of capital expenditures in 2020-2025 to renewables and low-carbon investments. But when confronted with investor skepticism about realizing renewable returns targets, Repsol's CEO Josu Jon Imaz surprisingly concurred: "I don't see Repsol being efficient in investing in the renewable sector everywhere without other kind[s] of linkages that could increase the return of these projects."[7] As an oil company unfamiliar with

[6] https://www.theguardian.com/environment/2009/jun/04/greenwash-total-renewables
[7] https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/repsol-ceo-warns-oil-company-s-climate-targets-may-be-tough-act-to-follow-56432805

the utilities sector, the firm may simply not be equipped to efficiently convert renewables investments into emissions-reducing assets.

Variation in strategies will depend both on firm-level choices, as well as the costs of decarbonization across sectors. For example, the falling cost of electric vehicles makes the transport sector relatively easier to decarbonize than, say, cement manufacturing. Thus, we could reasonably expect to see some firms moving toward a wholesale transition. To illustrate, General Motors has recently announced that it plans to produce only electric vehicles by 2035, investing $27 billion in the next five years.[8]

The oil and gas sector differs from most because transition requires fundamental changes in business activities. One cannot repurpose oil or gas wells to generate renewable energy. Moreover, even if some oil and gas companies decide to transform into renewable energy companies, they will face enormous write downs, since some assets will simply become stranded.

While these ideal-type strategies provide analytic clarity, empirically we expect measures of firm behavior to involve more mixed evidence. Some firms may follow a single, clear strategy, but many will likely end with some degree of "muddling through" (Lindblom, 1959). We categorize firms that mix strategies as hedgers, located toward the center of Figure 2. Given the constraints and fundamental technological challenges of decarbonization of the oil and gas industry outlined above, we expect the mix of strategies to weight more heavily towards hedging, resisting, and greenwashing, as indicated by the ovoid shape in the center.

There are strong theoretical reasons to expect hedging. First, decarbonization involves significant uncertainty. Firms must decide how to approach the decarbonization question without knowing exactly what technological, market, or regulatory pressures they or their competitors might be subject to over time. Because their business tends to require significant capital expenditure on assets that persist long into the future, firms must be very careful not to lock themselves in to a costly mistake, while balancing with investments already made. The same is true for adhering strictly to the status quo given uncertainties in the cost of carbon and the long-term demand for hydrocarbons. A mixed strategy may be optimal under such conditions to limit risks from opposing pressures: neither fully decarbonizing nor fully sticking with business as usual.

Second, there is ample evidence to challenge the assumption that firms act as unitary, internally consistent, rational actors. Oil majors are vast organizations, spanning multiple country offices, including multiple divisions and departments, and employing thousands. Organizational outcomes may reflect compromises across competing interests. Under these conditions, we should expect organizations to operate with bounded rationality, suggesting they may exhibit multiple strategies simultaneously. Total's strategy in India, for example, is characterized by CEO Patrick Pouyanné as "based on two pillars: renewables and natural gas"; while in Russia

[8] https://www.washingtonpost.com/climate-environment/2021/01/28/general-motors-electric/

and the Middle East, Pouyanné has steered the firm to maintain oil operations since its competitors there "are not prepared to stop producing."[9]

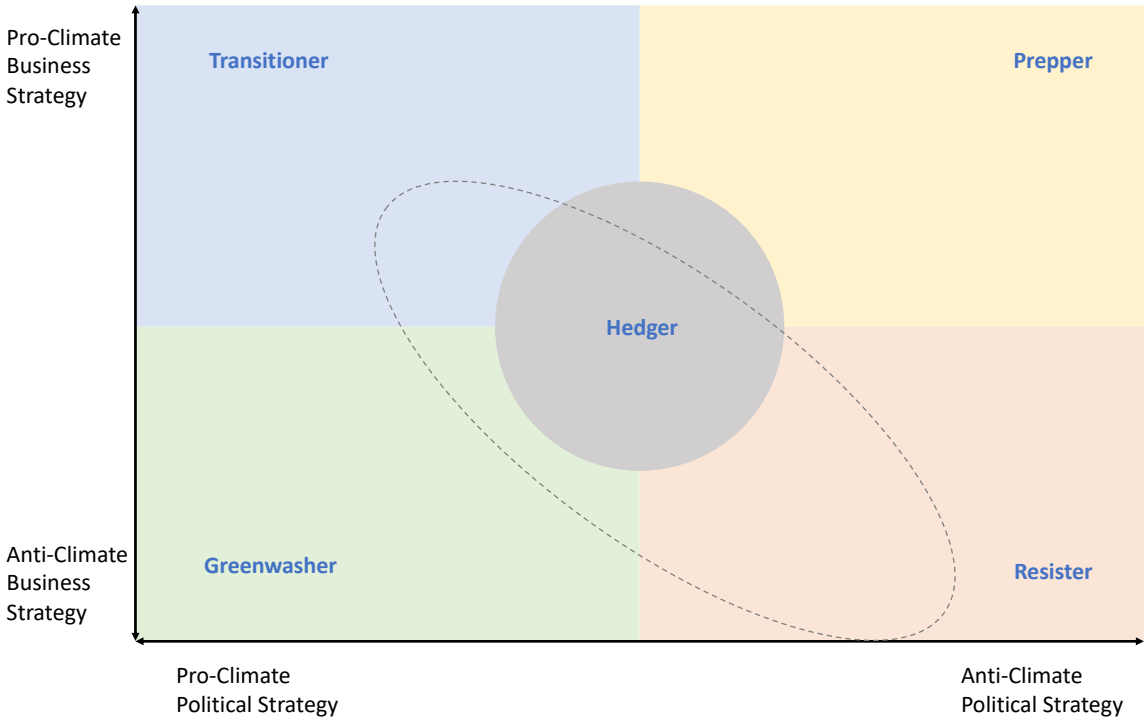

Figure 2. Ideal types of decarbonization strategies of oil and gas firms. *The y-axis represents the spectrum of firm strategy within business and operations; the x-axis represents the spectrum of firm strategy within policy. The dotted oval represents our expectation for the strategy of most firms.*

3. Theoretical expectations

How can we explain variation in firms' political and business behavior? We treat firms as boundedly rational, profit-seeking actors that respond to both market conditions and political opportunity structures. Specifically, we highlight three categories of factors that affect firms' strategies and behavior:

1. Firm assets and characteristics
2. Policy incentives firms face in the jurisdictions where they are incorporated, produce, and sell
3. Pressure from the firms' shareholders or stakeholders

[9] "Total deepens ties with India's Adani in $2.5bn green energy investment" (https://www.ft.com/content/f2c92d6f-eedd-478e-adbc-36fb45d5189b).
"Total chief warns of renewable energy bubble" (https://www.ft.com/content/0d3c0ea1-2643-4ceb-90ed-961d51f8123d)

Firms also respond to other market actors' behavior, but we do not address these interactions here. We explain the causal logic of specific variables in each of these categories in section 5, which examines correlates of firm behavior. Importantly, all three factor categories are partially endogenous: they do not just shape firm behavior but can, to some extent, be shaped by firm behavior. For example, a firm can shift its asset mix to adjust to changed market conditions, or can lobby governments to secure a more favorable regulatory environment. Firms may also be able to shift the behavior of their competitors by, for example, entering or exiting a certain segment of the market, or meliorate activist pressure by taking steps toward satisfying their demands. We should therefore understand firms' political and business behavior as continually dynamic and endogenously shaped by these different factors. Finally, firms may vary significantly not across these factors currently, but also in terms of their ability to shift these different categories of factors in the future. While this may present challenges for future causal inference, it captures the dynamic political nature of decarbonization.

We expect firm strategies to reinforce themselves over time. A firm that adopts a resistance strategy may find it difficult to become a transitioner in the future, perhaps because it has invested in fossil assets with long payback periods and devoted little attention to new business models. Similarly, a firm that has embraced transition may find it difficult to pull back if competitors have occupied a certain segment of the fossil value chain. The risk associated with such path dependencies creates additional incentives for most firms to cluster in the center as hedgers.

Within this overall pattern, we seek to identify firms most likely to move toward transition or resistance. Following our argument above, we expect firms will most likely be transitioners if: a) they face strong decarbonization policies in the jurisdictions in which they operate, and b) possess only marginal ability to shape future policies, either because of their own limitations or because they face adverse political conditions. We also expect firms most likely to profit from a decarbonized economy to be transitioners. This means that they expect to hold some competitive advantage in low carbon business models, and do not possess significant assets at risk of "stranding," such as fixed, long-term fossil fuel infrastructure. Conversely, we expect resisters to be firms for which the opposite is true. These expectations are summarized in Table 1. By the same logic, we expect firms not strongly characterized by these conditions to hedge.

Most likely to transition	*Most likely to resist*
1. Faces stronger decarbonization policies in one or more jurisdictions of operation 2. Has less scope to resist decarbonization policies politically (both because of its own attributes and the jurisdictions it operates in) 3. Has comparative advantage in low-carbon business models 4. Depends on shareholders / stakeholders demanding transition	1. Faces weak decarbonization policies in one or more jurisdictions of operation 2. Has significant scope to resist decarbonization policies politically (both because of its own attributes and the jurisdictions it operates in) 3. Has comparative advantage in status quo business models 4. Is insulated from shareholders / stakeholders demanding transition

Table 1: Summary of expectations regarding firm variation.

4. Measuring decarbonization behavior

Our approach to measuring firm behavior focuses on publicly-visible political and business activities of the top ten investor-owned oil and gas firms by market capitalization, including: BP, Chevron, ConocoPhillips, ENI, Equinor (formerly Statoil), ExxonMobil, Occidental Petroleum, Repsol, Royal Dutch Shell, and Total. Our analysis spans from 2004-2019.

A number of policy and finance-related reports have mapped variation in either business or political behavior of oil and gas companies (Caldecott et al 2018, Chaudhry and Law 2018, Dietz et al 2018, Fletcher et al 2018, Nasiritousi 2017, Pickl 2019). Our analysis departs from these works in two ways. First, we create an original measure of firms' political behavior, coding their speech on quarterly earnings calls to investors. This new measure provides detail about different aspects of firms' political stances while also creating more comparable measures across a wider sample than previous approaches. We then incorporate both business and political dimensions into a single theoretical and empirical framework, creating a new systematic and robust measure of the extent to which firms are progressing towards decarbonization. Second, while many of the existing mappings look only at a single cross-sectional snapshot, our approach tracks firm behavior over time.

Measuring firms' climate-related political behavior

Existing work has primarily measured firms' political behavior via lobbying activity, relying principally on qualitative measures of firms' political engagement or quantitative measures of lobbying and public relations expenditures, predominantly in the United States (Delmas et al., 2015; Grumbach, 2015). The most systematic publicly available measures have been created by the NGO InfluenceMap, providing a useful look at firms' behavior and, critically, capturing "actions" (spending) as well as speech. At the same time, the InfluenceMap data has significant limitations, including its U.S. focus and an inconsistent methodology year-to-year.

Our measure of political behavior uses firms' speech in shareholder meetings ("earnings calls") to code their positions regarding climate policies. Earnings calls are regular (typically quarterly) interactions between firms and their major investors. They are the primary way in which firms communicate to capital markets, and therefore have a significant impact on share prices. Information conveyed in earnings calls can be used to hold firms accountable in legal proceedings. This makes their content relatively "costly" speech for firms. We can interpret firms' speech in such settings as what managers think capital markets want to know about their business.[10]

We draw on a textual database of 1,747 publicly-reported quarterly earnings calls from 2004 to 2019. To capture political activities regarding climate policy, we coded speech from these calls for six key indicators: (1) acceptance that fossil fuel use will ultimately end, (2) acceptance of climate science, (3) attitudes towards carbon pricing, (4) support for international agreements,

[10] Notwithstanding the limitations of InfluenceMap's data coverage, we cross-validate our measure with all four InfluenceMap indicators for which there are data. Our measure is positively correlated with all four, and significantly correlated with firms' total spending on climate-related PR and with subjective "grades" of firms' climate policy. See Table A3.

(5) support for national laws, and (6) attitudes towards carbon capture and storage (CCS). Each of these indicators assesses the degree to which firms' public statements express commitment to, and urgency around, climate change.

We first search earnings call text for mentions of keywords related to each topic and then code the valence of these mentions as either accepting, partially accepting/neutral, or rejecting a climate policy or indicator, according to a codebook developed by the researchers.[11] These instances are then aggregated at the firm-quarter level and assigned a score that maps onto our theoretical spectrum ranging from -1 (fully opposing) to +1 (fully supporting). Further details on coding decisions for these indicators are provided in Table A2, along with an example of coding firms' acceptance of climate science.

There are limitations to this measurement strategy, however. First is temporal coverage: public records of earnings calls are only consistently available starting in 2005. While several important developments in sectoral strategy occurred in the 1990s in the buildup to Kyoto, the available data still allow for a longitudinal analysis over 15 years, including 10 years of earnings calls prior to the Paris Agreement. Second, earnings calls are typically only available for publicly traded firms, which omits national oil companies like Saudi Aramco or Rosneft as well as smaller independent oil firms. Third, we acknowledge the possibility that public support in favor of climate policy could still coexist with private lobbying against climate policy. However, the limited data that are available suggest otherwise: our earnings calls measure tracks positively with the InfluenceMap measure of total lobbying spend in the US that is net in favor of climate policy, though the data from InfluenceMap are quite sparse (Table A3). Moreover, as we note above, statements made in earnings calls would raise liability concerns in legal proceedings brought by shareholders, and thus should be considered as costly speech.

Measuring firms' climate-related business behavior

Many studies analyze firms' future plans for decarbonization. At the time of writing, there are a slew of firm announcements presenting a wide array of climate targets, many framed as net zero. We do not attempt to summarize this rapidly changing landscape of forward-looking announcements here, but instead note that current reports suggest little commitment to full decarbonization. For example, Climate Action 100+ notes that of 39 oil and gas companies, 24 have set long-term quantitative targets for reducing GHG emissions (2019, pp. 21-26). But none of these companies is committed to an absolute CO2 reduction target that includes indirect emissions generated throughout its value chain (i.e. scope 3). By contrast, a number of firms have committed to less stringent carbon intensity targets, or sometimes paired with significant investments in offsets or, in the case of Occidental, carbon removal technology. Meanwhile, all firms are planning significant expansion of oil and gas assets, totalling some USD$1.4 trillion in the period 2020-2024 (Oil Change International 2019). This is wholly inconsistent with meeting the Paris goal of pursuing efforts to limit warming to 1.5 degrees Celsius (Dietz et al. 2020).

[11] This coding was completed by a team of four research assistants who overlapped in their coding. After training, a reliability analysis indicates there is substantial agreement across coders for all variables (percent agreement >90% and Cohen's Kappa >0.61).

While analyzing plans can be useful, notably for the cross-firm variation they reveal, such studies are unable to distinguish true intentions from strategic ones, and, perhaps more importantly, to predict the many uncertainties that will shape firm behavior in the future. Even firms that genuinely intend to meet their current targets may find themselves moving in a different direction (for example, BP's original "Beyond Petroleum" campaign was ultimately unraveled).

To avoid these pitfalls, we focus on past firm behavior, not stated intentions about the future. On the business dimension, four different activities construct an overall picture of firms' decarbonization efforts in the sector: emissions (total carbon emissions and flaring), energy efficiency, upstream oil commitments (oil production mix and average reserve life), and renewables and other non-oil investments. Table A1 provides further details on our coding for the first three indicators, which are all drawn from well-established industry measures.

We measure investments into renewable energy and non-oil activities using data on publicly-reported joint ventures, mergers & acquisitions, and equity investments from 2001 to 2019. Deal value amounts are only available for 59% of the sample (71 out of 121 investments), so we only draw tentative descriptive inferences about differences in investment values across firms.[12] We group investments by technology and distinguish between those that align with the core business model and skill set of oil and gas firms and those that do not.[13]

This "core" versus "non-core" distinction allows us to evaluate the extent to which firms remain committed to fossil fuels and fossil-fuel infrastructure. For example, a firm investing heavily in CCS and biofuels is betting on the continued extraction of hydrocarbons and use of internal combustion. By contrast, a firm investing in solar manufacturing and electric vehicles foresees the end of a fossil-fuel-dependent energy system.

These indicators are then standardized to allow for comparability with the political dimension. The endpoints are determined based on indicator values that conform to the spectrum described above, from significant disruption to business model (-1) to no disruption (+1). For example, the endpoints for the upstream oil indicator range from a full BAU of 100% oil in the production mix and an average reserve life of at least 11 years to a BAU-disruptive 0% oil in the production mix and an average reserve life of 0 years; the latter would be the case for a firm that has completely abandoned crude oil operations and replaced it with either gas or non-hydrocarbon operations. In terms of renewables and non-oil investments, the scale ranges from no investments made in a given year or prior year (-1) to at least one investment made in a given year (+1). For example, Chevron invested in solar thermal technology in 2011, so it is coded as +1 for 2011, 0 for 2012, and -1 afterwards since it made no other investments in 2015-2019.

[12] We examine differences in the types of investment instruments across firms, which we report in Figure A1.
[13] Core skill set investments include: non-renewable electricity (e.g., gas power plants), offshore wind, biofuels, financial services, and carbon capture and storage. Non-core skill set investments include: solar and onshore wind, power infrastructure (including energy storage), hydrogen, electric vehicles, and nuclear.

5. Mapping Variation in Firm Decarbonization Behavior

We average both sets of indicators to assess firm variation in decarbonization strategies using the structure illustrated in Figure 1 above.[14] Figure 3 presents the results by firm. Overall, we find little evidence of disruptive change in firms' business behavior, with the "best" achievers engaging in hedging, through a shift toward natural gas. Politically, there has been more progress. Firms are generally more acceptant of climate science and of the intergovernmental process post-Paris, but virtually none accepts the end of the fossil fuel era. The disconnect between business and political behavior raises questions about the extent to which the latter is indicative of meaningful future changes.

The top panel shows average political and business activities for the 2004-2014 period while the bottom panel shows the 2015-2019 averages.[15] These two sub-periods represent a high-oil-price environment (on average, $89.61 per barrel) and a low-oil-price environment (on average, $55.41 per barrel), respectively, while also capturing the heightened attention to climate policy that preceded the 2015 Paris Agreement.[16]

Figure 3 shows the negligible progress on decarbonization. No firm in the sample is pursuing a transition strategy; firms are instead either hedging or resisting. Hedgers include those in the middle of the plots: Equinor, Shell, BP (post-2014), and Total. Resisters, in the bottom right of the quadrant include: Chevron, ConocoPhillips, ENI, ExxonMobil, and Occidental Petroleum.

Consistent with our expectations, the overall pattern in the post-2014 period reflects a positive correlation between firms' business and political strategies. The firms with the most anti-climate political strategies, such as Chevron, also exhibit the most anti-climate business strategies. Likewise, politically pro-climate firms like Equinor and Total pursue the most pro-climate -- or, more accurately, the least anti-climate -- business strategies.

Two exceptions stand out. BP is pro-climate politically after 2014 (Figure 3, bottom), but lags behind Equinor, Shell, and Total in terms of pro-climate business activities.[17] By contrast, ConocoPhillips is among the most anti-climate firm along the business dimension, though fairly centrist in its political strategy. Overall, however, all firms fall within our expected range in Figure 2, especially after 2014.

[14] There are several alternatives to using averages for dimensionality reduction. A priori, we have no reason to veer from assigning uniform weights for each indicator, so a simple average for each dimension provides a reasonable and interpretable estimate of a firm's business and political strategies.
[15] While we have data on business activities from 1998, we do not have information for all firms on earnings calls prior to 2004.
[16] Average oil prices from the *BP statistical review of energy* using Brent spot crude price.
[17] Prior to Paris, BP was among the most anti-climate firms politically: it sowed considerable doubt in climate science, did not accept the need for capturing carbon, and pushed back on domestic environmental regulations such as the US fuel efficiency standard as late as June 2014.

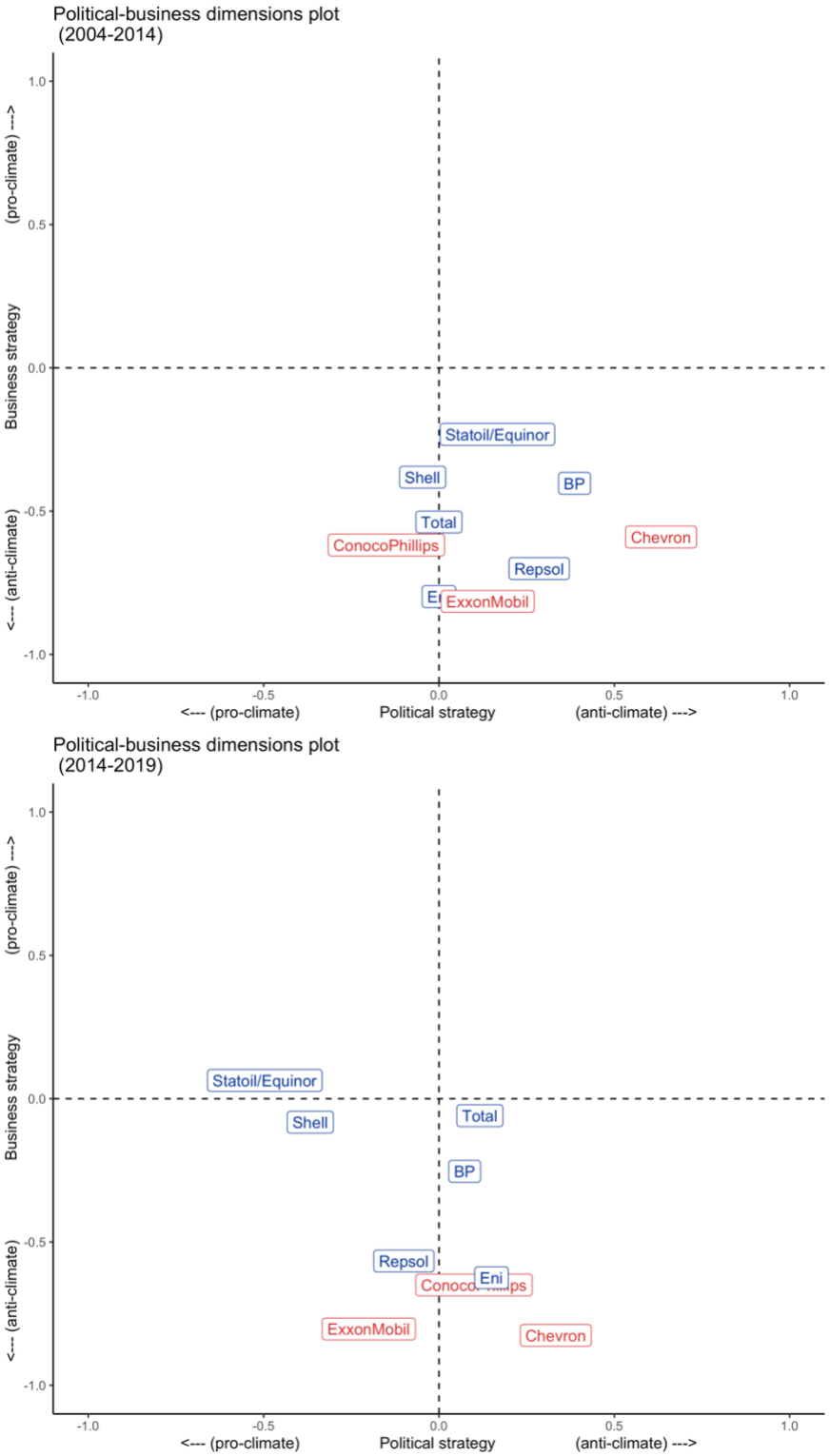

Figure 3. Variation in firm decarbonization activities in the oil and gas sector, pre-2014 (top panel) and post-2014 (bottom panel). *North American firms in red; European firms in blue.*

Business model variation

We find remarkably little within-firm temporal variation along the business dimension (comparing the top and bottom panels of Figure 2). This reflects a broader pattern of limited changes to the business model of major oil firms along our indicators (Figure 4). Though firm emissions have declined overall, they remain flat over time on a per dollar basis (Figure A2). There is progress on eliminating flaring, though no firm has achieved the zero flaring target set forth by the World Bank's Global Gas Flaring Reduction Partnership. All firms in the sample are members.

We do find a general shift to natural gas as evidenced by the slow movement away from upstream oil investments, though again progress is limited. For example, no firms are completely withdrawing from crude oil production and, aside from Repsol, the plurality of production across firms is still in oil. There are similarly modest reductions in average reserve life, which has decreased for most firms. ExxonMobil and BP are exceptions; their average reserve life has increased over the period. Overall, this is a stark reminder that most firms are still committed to conventional upstream projects, effectively locking in continued oil production for at least 11 years on average. And while switching to gas reduces intensity, it also locks in fossil production into the future (Seto et al., 2016).

Investments in renewables and non-oil activities not far from the core skill set of oil and gas firms -- such as offshore wind, biofuels, and gas power plants -- represent a miniscule proportion of firm investment. The sharp rise in the 2003-2009 period only increased investments to roughly one-half of 1% of total revenue, and declined thereafter. This tracks closely with the near-monotonic rise in oil prices from late 2001 to mid-2008, before the price crash sparked by the global recession. The pattern in noncore investments follows a similar trend, but there is a marked increase in 2017-18, largely because of an uptick in solar investments by BP, Equinor, Repsol, Shell, and Total.

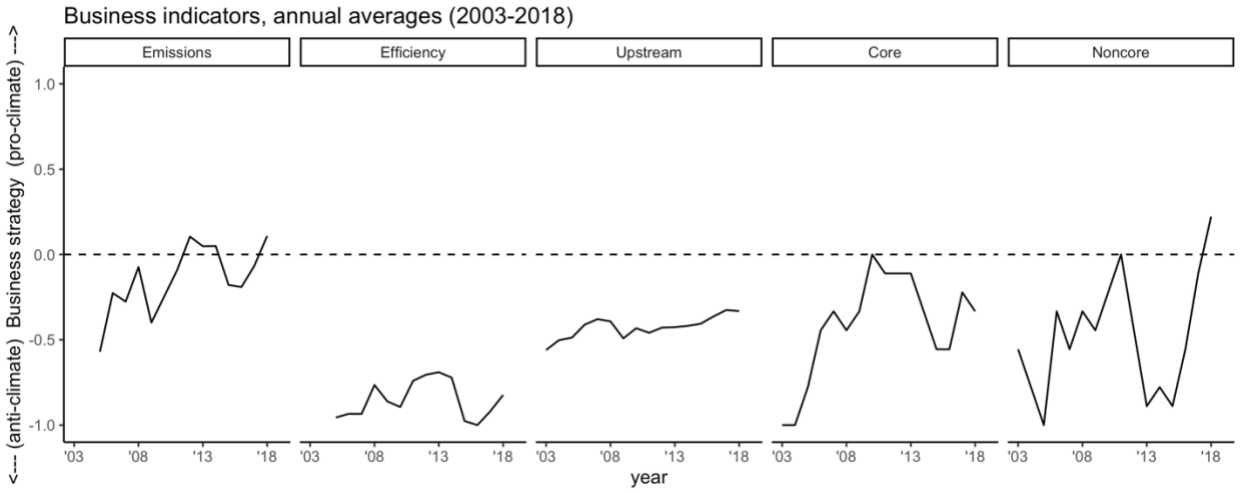

Figure 4. Firm business strategy, by indicator. *Each indicator is standardized to a scale running from no disruption from BAU (-1) to full disruption of BAU (+1).*

Separately, we also consider the *value* of firm investments in renewable energy projects, though there is incomplete information for 41% of investments. Further, we do not have a proper denominator to track the relative importance of renewables to the overall investment portfolio of each firm; instead, we proxy for total investments using total revenues. Data limitations notwithstanding, we do not expect our patterns to significantly differ, given that investment growth largely tracks total revenue growth.

Although some firms have made progress in renewables investments over this period – namely, Equinor, Total, and Repsol – they pale in comparison to overall firm revenues. Not a single major oil and gas firm has invested more than 0.1% of revenues into renewable energy (Figure 5). This is further evidence that no firm has committed to a decarbonization energy system at any meaningful level, tempering optimism about the potential for voluntary initiatives to trigger transformative change via this mechanism.

In addition, several firms lag in renewables investments over time. These firms, shown with downward sloping cumulative shares in Figure 5 (right panel), made renewables investments in the early-2000s, but they have either stopped entirely or diminished in value since the post-recession oil price increase starting in 2009. Between 2010 and 2018, for example, neither ExxonMobil, Chevron, nor ConocoPhillips made any significant investments in renewable energy projects.[18] Overall, these patterns reflect a continental divide that we find across our set of business indicators: European firms are, on average, making greater investments into renewable energy projects than American ones.

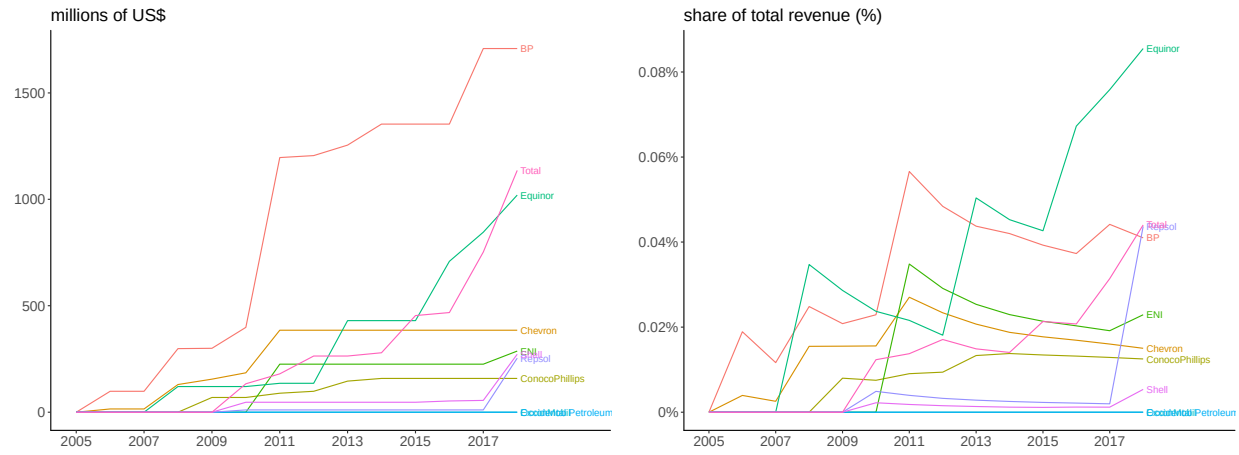

Figure 5. Cumulative renewables investments, 2005-2018. *The left panel shows the cumulative sum of annual investments in renewable energy projects in millions of US dollars. The right panel shows this value as a share of total firm revenue.*

When viewed relative to BAU, all of our business indicators suggest limited variation in decarbonization efforts across firms over time. While there are some exceptions – declines in gas flaring, and a general shift to natural gas instead of oil – overall, there is little movement away from the core fossil fuel business model.

[18] Shell ranks low in our cumulative share figure due to missing data. However, it made 18 investments into renewables companies between 2005 and 2019, third among all firms in our sample.

Political variation

By contrast, we find significant variation in firms' political decarbonization strategies over time. Between 2004 and 2014, nearly all firms deployed anti-climate public-facing rhetoric (Figure 3, top). With the exceptions of ExxonMobil and BP, there is a clear shift among oil and gas firms towards more a pro-climate political strategy after 2014 (Figure 3, bottom). That said, no firm unequivocally adopts a pro-climate political strategy. Rather, firms cluster in the middle, either adopting "soft opposition" or "soft support" for climate policy between 2015 and 2019.

The middle cluster of firms diverges between slightly pro-climate European firms (Equinor, Shell, Total, and Repsol) and slightly anti-climate American firms (ExxonMobil, Chevron, ConocoPhillips, and Occidental). Interestingly, BP and ENI are much closer in political strategy to this latter group of firms rather than to their European counterparts.

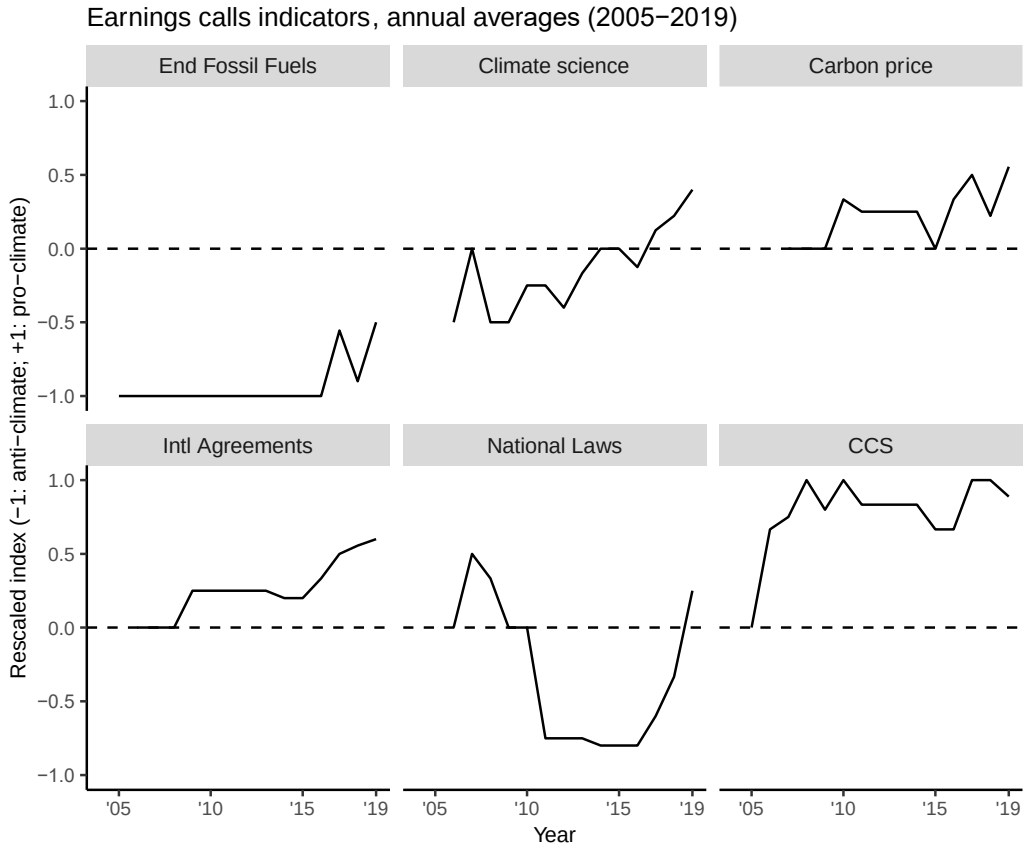

Figure 6. Firm political strategy, by indicator. *Each indicator is standardized to a scale running from strong effort against climate policy (-1) to strong support for climate policy (+1). See Table A2 for unscaled endpoint values for each indicator.*

Parsing the indicators, much of the shift in firms' political strategies is concentrated in a decreased effort to deny climate science and a growing acceptance of a carbon price (Figure 6). Given that Europe adopted a carbon price in 2005, this is a rather low bar. There is also more support for international climate agreement, particularly after the signing of the Paris Agreement in 2015. The voluntary nature of the Paris Agreement, and the associated non-state actor pledges

explains these shifts. Mitigation efforts would come from the "bottom up," and therefore need not be as costly as under the previous Kyoto regime. In order to support international action and associated policies like carbon pricing, accepting the science was a necessary condition.

Despite these upward trends, firms steadfastly deny the end of fossil fuels across all years of the sample. In the 2008-2016 period in particular, we find the emergence of sharp resistance to the idea that fossil fuels will be phased out in the energy transition. While there is some movement away from the BAU assumption of the endurance of fossil fuels in 2017-2019, no firm has yet publicly made an effort to support a fully decarbonized energy system.

6. Exploring the Correlates of Decarbonization

To assess our theoretical framework, we incorporate our data on firm characteristics and opportunity structures to determine the correlates of firm behavior. As noted above, our approach leads us to expect that "transitioners" will: a) face stronger decarbonization policies; b) have less scope to resist those policies; c) have a comparative advantage in the new decarbonized business model; d) face more shareholder pressure. "Resisters" should have the opposite characteristics. Firms not strongly characterized by these dimensions will tend to "hedge" in their strategy.

We probe the plausibility of these hypotheses with a simple linear regression analysis using a panel structure with firm-year as the unit of analysis. Our original data examines the decarbonization behavior of the 10 largest firms from 2008 to 2018.[19] Table 2 contains information about measurement and data sources; descriptives are in Table A4. Attribute data for Occidental is unavailable due to non-reporting; we also encountered significant missing data from other firms prior to 2010, limiting our sample size.

We employ three dependent variables: 1) the annual firm score on the political dimension of decarbonization (*pro-climate political behavior*); 2) the annual firm score on the business dimension of decarbonization (*pro-climate business behavior*); 3) the sum of the annual firm scores on both dimensions (*overall decarbonization)*. As explanatory variables, we include firm attributes such as R&D investment, sales diversification, and refining capacity, as well as attributes of the jurisdictions in which they operate, membership in climate coalitions, and time varying trends in oil prices. These measures investigate our four postulates and reflect variables previously used in the literature on oil and gas firms (e.g., Bach 2019; Grumbach 2015; Levy and Kolk 2002; Nasiritousi 2017; Pickl 2019). All models include robust standard errors to account for clustering by firm.

[19] We are unable to compile a complete dataset for our covariates for 2019.

Variable	Description	Measurement	Data Source
Emissions Regulation in HQ	Stringency of emissions regulation in the country where the firm has its headquarters	CPI index, range 1-100	Original coding of firms' annual reports; Climate Change Performance Index
Emissions Regulation in Market	Stringency of emissions regulation in the country where the firm sells the largest share of its product	CPI index, range 1-100	Original coding of firms' annual reports; Climate Change Performance Index
Emissions Regulation in Production	Stringency of emissions regulation in the country where the firm produces the largest share of its product	CPI index, range 1-100	Original coding of firms' annual reports; Climate Change Performance Index
R&D Expenditures	Expenditures on research and development as a share of total firm expenditures	Percentage	Bloomberg Energy
Climate Resolutions	Number of climate-related shareholder resolutions filed against a firm	Number of resolutions	Interfaith Center of Corporate Responsibility
Coalition Membership	Firm's membership in the Oil and Gas Climate Initiative, the Carbon Disclosure Project, and the Global Gas Flaring Reduction Partnership	Sum of the total number of memberships	Original coding of coalition membership rosters
Average Oil Price	Average price of for one barrel of oil	Annual average of the WTI and Brent indices	Bloomberg Energy
Diversification	Extent to which a firm's sales are concentrated in one market	Percentage of sales outside of the largest market per year	Original coding of firms' annual reports
Refining Capacity	Size of a firms refining sector	Log of the daily processing capacity of crude oil distillation units, in million barrels	Bloomberg Energy

Table 2. Data Sources and measurement for firm characteristics and opportunity structures

Table 3 contains the results from the regression analysis. Model 1 considers the *overall decarbonization* dependent variable (the sum of the scores on the political and business dimensions) and the effect of emissions regulations in the jurisdiction in which the firm has its headquarters. Model 2 considers *overall decarbonization* and the effect of emissions regulations in the jurisdiction in which the firm sells the largest share of its product. Models 3 and 4 consider solely the *pro-climate political behavior* and *pro-climate business behavior* dependent variables, respectively.[20]

The first three models have fairly consistent results and explain a good portion of the variation. The effect of emissions regulation in the country in which a firm's headquarters is located is

[20] Standard errors for these last two models are largely unchanged if we instead use a seemingly unrelated regression (SUR) model that simultaneously estimates both the business and political DV models.

positive and significantly associated with *overall decarbonization*, suggesting that firms headquartered in jurisdictions with more stringent regulations are more likely to decarbonize. Similarly, emissions regulation in a firm's main market also has a positive and significant relationship with *overall decarbonization*, although the effect size is smaller. It matters, then, where a firm's customers are located. In addition, the size of the refining sector in a firm (recall, larger refining operations imply less ability to shift to a low-carbon business model) has a negative and significant relationship with decarbonization. Finally, membership in voluntary corporate climate initiatives is positively and significantly associated with *overall decarbonization*.

Our results change somewhat when we consider the two dimensions separately. In Model 3, we see that firm diversification is positively and significantly associated with *pro-climate political behavior* but not with the other dependent variables. We also see that oil prices are negatively associated with *pro-climate political behavior* though this finding is not statistically significant. Model 4 indicates that *pro-climate business behavior* is positively and significantly associated with higher oil prices, though other firm and jurisdiction traits are not significantly associated with business behavior. Contrary to the previous models, firm diversification and R&D expenditures are negatively associated with *pro-climate business*, although not significantly so.

	Model 1 Overall	Model 2 Overall	Model 3 Political	Model 4 Business
Emissions Regulation HQ	0.103***		0.079**	0.024
	(0.027)		(0.027)	(0.017)
Emissions Regulation Market		0.059**		
		(0.020)		
Diversification (percent)	0.004	0.006	0.008**	-0.004
	(0.003)	(0.005)	(0.003)	(0.004)
Refining (log)	-0.459**	-0.509**	-0.388**	-0.071
	(0.174)	(0.200)	(0.120)	(0.072)
R&D (percent)	0.028	0.092	0.058	-0.030
	(0.116)	(0.105)	(0.121)	(0.019)
Coalition Membership (sum)	0.448***	0.538***	0.301**	0.147
	(0.107)	(0.130)	(0.086)	(0.091)
Oil Prices	0.247	0.383	-0.183	0.430*
	(0.355)	(0.284)	(0.370)	(0.209)
Constant	-6.899**	-3.543	-4.820*	-2.079
	(2.737)	(2.325)	(2.479)	(1.213)
Observations	63	63	63	63
R-squared	0.609	0.512	0.545	0.395

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3. Factors predicting firm decarbonization strategies

We assessed the robustness of these findings with additional analyses reported in the Appendix. Our findings are robust to different modeling approaches, including using a random effects model, and including year as an independent variable and as year fixed effects.

We also experimented with using alternative measures for our core political variables of interest. In particular, scholars have often theorized a "continental divide," attributing the relative strength of European climate policies to, inter alia, corporatist arrangements, proportional representation, less scope for campaign contributions, and European integration – all factors that should reduce the abilities of oil and gas firms to shape public policy (Levy & Kolk, 2002; Mildenberger, 2020; Skjærseth et al., 2013). We find that using a binary variable measuring whether firms have their headquarters in the EU in place of the country-level emissions regulation variable does not substantially change the results and decreases model fit. This suggests that there is significant intra-EU variation that is better explained by examining country-level policy. We also explored using a variable measuring the percentage of GDP that the firm's headquarters country derives from natural resource extraction and found similar results. Although we encounter data limitations, we also do not find that measuring environmental policy stringency significantly alters the results. These results are reported in the Appendix.

We also sought to evaluate other hypotheses that were not suitable for testing in this framework due to data limitations. We attempted to evaluate the effect of emissions regulation in the country in which the firm conducted the largest share of its production but encountered a great deal of missing data across all firms throughout the time period. For the cases with sufficient data (n= 65), emissions regulation in the main country of production is moderately correlated with *overall decarbonization* (0.40, $p < 0.001$). Similarly, we were interested in testing the effect of shareholder resolutions on decarbonization behavior using data from EthVest. Unfortunately, we were only able to identify a reliable data source for such resolutions for a subset of the firms in our analysis: BP, Chevron, ConocoPhilips, ExxonMobil, and Shell. In this more limited set of firm-years (n=38), climate resolutions are weakly negatively correlated with *overall decarbonization* (-0.14, p=0.42) as are renewables resolutions (-0.04, p=0.79). This may reflect that shareholder advocates tend to target the worst offenders.

Overall, our findings point towards several conclusions. Across all our models, the policy stringency of the country in which the firm is headquartered and sells its product was significantly correlated with its decarbonization behavior. Because firms rarely switch jurisdictions, we have limited ability to assess whether the relationship suggests that regulation has a causal influence on firm behavior. Our theory suggests that firms working in jurisdictions with more stringent decarbonization policy will have less scope to resist such policies. But it could also be the case that firms that plan to adopt a transition strategy will be less likely to oppose stringent climate regulations. We particularly note that regulation seems to be a much stronger predictor of political behavior than business behavior, suggesting that firms make an effort to align their policy but not necessarily business practices, with regulators' goals, or that political commitments may not readily translate into business practices.

Similarly, the size of the refining sector correlates with opposition to decarbonization in all our models, although it loses significance in the business model. Companies with a larger refinery footprint are the least flexible in a carbon-constrained world, so they should be more likely to

resist transitioning. Firms with large refining sectors may therefore have large internal constituencies pressuring the firm to resist. It is difficult to reconfigure refineries to handle different types of crude oil, such as ultra-light oil versus extra-heavy oil (the latter being more carbon intensive). A more stringent climate regime will force refinery owners to either undertake costly retrofits or write down their assets entirely. Given that we do not know the carbon-intensity of the refineries owned by these firms, we cannot be entirely sure that this is the mechanism at work, yet it is one possible pathway to explain the negative correlation.

We also find that membership in industry coalitions has a consistently large, positive relationship with decarbonization in three of our models. It does not obtain in the *pro-climate business behavior* dependent variable, suggesting once again, that these initiatives produce more promises than outcomes. Traditional accounts emphasize that firms are positively influenced by their peers in the context of such coalitions, improving their decarbonization performance. Yet it can be difficult to establish causality in such settings because of extensive self-selection. Although we suspect that firms that intend to decarbonize are more likely to join industry coalitions, we also note that lagged membership (for up to three previous years) remains a significant predictor of decarbonization behavior by firms (see Appendix). Thus, we cannot determine whether firms join coalitions and are influenced by their peers or whether they join coalitions in anticipation of their future behavior.

Several other variables did not appear to be statistically significant in our models but deserve further attention. Firms with greater market diversification for their products tend to be more likely to hedge, especially on the political dimension. They may prefer a political strategy that promotes harmonization across jurisdictions with different levels of regulation (Vogel & Kagan, 2004). In contrast, and consistent with our theory, diversification is weakly negatively associated with *pro-climate business behavior*, likely capturing the fact that a few U.S. firms are both highly concentrated in their sales and perform poorly on the business dimension. As expected, R&D expenditures are generally positively associated with *overall decarbonization and pro-climate political behavior*, reflecting the idea that more "innovative" firms are more able to shift strategies. Somewhat puzzlingly, we find a negative correlation between R&D and *pro-climate business behavior*. This could reflect a different kind of mixed strategy: Total, for instance, simultaneously invests in renewable energy and upstream oil projects, perhaps in an effort to maximize profitability under uncertainty.

Finally, firms tend to engage in more pro-climate business behavior when oil prices are high, perhaps reflecting that additional revenue can be repurposed for this goal. Firms engage in more pro-climate political behavior when oil prices are low. This could indicate increased firm confidence about the future viability of fossil fuels, given the perception that low oil prices decrease the competitiveness of alternative energy solutions. Taken together, these two results would suggest a non-linear relationship between oil prices and decarbonization strategies, though more research is needed to explain the mechanisms underpinning such a relationship.[21] This is consistent with other work that conceptualizes decarbonization as a process of overcoming carbon lock-in (Unruh, 2000).

[21] Henriques & Sadorsky, 2011 find a similar non-linear relationship between oil price volatility and the general investment levels of non-financial firms.

Overall, these findings provide evidence to support our theoretical expectations. We note that there are several important limitations to our analysis. First, our statistical analysis provides us with limited leverage to assess the direction of causality underlying observed correlations. Second, collecting data on the attributes and behavior of firms is significantly more difficult than collecting data on public actors, resulting in a substantial amount of missing data, limiting the statistical power of our analysis. Third, many of our variables of interest at the firm level and jurisdictional level are highly correlated and thus cannot be included simultaneously in a single model. Fourth, data availability limits the time period of our analysis to only the most recent period. As a result, we are not able to include many of the significant developments in this field that occurred in the 1990s. Considering these limitations, future research is needed to illustrate the mechanisms by which these variables may be related.

7. Looking Ahead: Prospects for Transition

Our analysis of the political economy of oil majors' decarbonization efforts yields three main findings. First and most importantly, firms are not decarbonizing. Rather, they are hedging, greenwashing, or resisting. Second, headquarters' location matters: firms headquartered in countries with stricter regulations are more likely have pro-climate behavior on both political and business dimensions. Thus, domestic policy, not global conditions, dictates the pace of decarbonization. Second, though some firms have improved their business behavior, this has mostly occurred through a shift to gas, with minimal investments in renewables. Transitioning has not yet occurred. Third, firms increasingly accept climate science and support the Paris Agreement and carbon pricing. Yet accepting climate science is a very low bar, and neither policy is sufficient to promote decarbonization.

Is our approach generalizable to other sectors? We think that our theoretical exploration of the two dimensions of decarbonization – political and economic – and the resulting ideal types may be applied both to national oil companies (NOCs) as well as other industries facing the decarbonization dilemma. The choice of strategy will likely depend on the costs firms face and jurisdictional regulations. In considering the applicability to NOCs, two key variables -- government policy and firms' ability to change -- stand out. On policy, our findings regarding the centrality of the home jurisdiction should be *truer* for national oil companies than the firms considered here. In general, we should expect laxer policy in nations with large NOCs and carbon-intensive state-owned enterprises in general. Nasiritousi (2017) demonstrates that NOCs tend to be less active in climate governance activities and less subject to external pressures from stakeholders, further supporting the importance of these dimensions in driving firm choices. More broadly, our framework could be applied to other sectors. Disaggregating the political and economic behavior of firms across sectors would allow other researchers to detect inconsistencies; we should not always expect that these two dimensions move in lockstep.

We reiterate that our analysis of firms' past behavior does not predict future behavior. Rather, given that the previous two decades do not provide much evidence for transition, the major research question implied by our analysis is: what forces might be sufficient to change the status quo of previous decades? We conclude by highlighting several dynamics that may alter the dynamics of decarbonization away from the incremental change of the past two decades.

First is the ongoing COVID-19 crisis. The economic impact of the crisis is still unknown, as are potential long-term structural shifts it may leave behind (e.g. permanently reduced demand for commuting and travel). A large, sustained shock in demand for oil and gas products may have differential impacts on oil and gas companies. A number of the oil majors have taken massive write-downs in the wake of COVID-19. However, recall that our period of analysis includes the 2008 financial crisis, which seemed to have little effect on the rate of decarbonization.

Second, United States' climate policy is critical. As both a major oil and gas producer and consumer, and as the headquarters of several oil and gas majors, aggressive policies in the Biden Administration could have considerable impact. In turn, we could expect greater convergence across US and EU firms, which could produce further progress on renewables. More generally, as noted above, the role of domestic politics and institutions cannot be understated.

Third, it is unclear how firms are affected by other firms' actions. Aggressive transitioning by some firms will create countervailing effects on others. Positively, such changes may allow for the adoption of more stringent climate policies, which may in turn exert pressure on resisters. But, negatively, such moves could also increase the market share of resisting firms, enhancing their ability to resist change and be the "last one standing" in the oil sector. Which tendency prevails depends on the ability of firms to shape their political environment and firms' ability to shift business models. For example, there could be a scenario in which Europe benefits from the positive self-reinforcing dynamic, as greater regulatory pressure, less scope for firm resistance, and more firm adaptability creates conditions toward greater decarbonization. Conversely, the US could suffer a negative feedback, in which weak regulations are insufficient to pressure incumbent firms with legacy investments and relatively cheap, long-lived fossil assets, notably natural gas.

Acknowledgements

Research for this paper, and discussion at several research meetings, was made possible by generous funding from the Balzan Foundation under the terms of a prize awarded in 2017 to Professor Robert O. Keohane and administered by Princeton University and the Center for Advanced Study in the Behavioral Sciences under his supervision. We thank the participants of those meetings, as well as participants at the UCSB Environmental Politics Workshop and the ANU Crawford School of Public Policy Virtual Conference on Charting the Future Political Economy of Oil, for their feedback. We also acknowledge the excellent research assistance of Charlie Bain, Ollie Ballinger, Adam Bouyamourn, Alexandra Dildine, Rebecca Jane Lorenzen, Yangsiyu Lu, Elena Pierard Manzano, Peter Suechting, and Noosha Uddin.

Declaration of interest statement

The authors have no conflicts of interest to declare.

Data availability statement

All data will be available on the Harvard DataVerse (https://dataverse.harvard.edu/)

References

Bach, Matthew. 2019. The oil and gas sector: from climate laggard to climate leader? *Environmental Politics* 28 (1): 87–103.

Breetz, Hanna, Matto Mildenberger, and Leah Stokes. 2018. The political logics of clean energy transitions. *Business and Politics* 20 (4): 492–522.

Brulle, Robert J. 2018. The climate lobby: a sectoral analysis of lobbying spending on climate change in the USA, 2000 to 2016. *Climatic Change* 149 (3): 289–303.

Caldecott, Ben, Ingrid Holmes, Dileimy Orozco, Shane Tomlinson and Lucas Kruitwagen. 2018. *Crude Awakening: Making Oil Major Business Models Climate-Compatible*. E3G Report.

Cashore, Benjamin, Graeme Auld, and Deanna Newsom. 2004. *Governing Through Markets: Forest Certification and the Emergence of Non-state Authority*. New Haven: Yale University Press.

Climate Action 100+. 2019. Progress Report. Available at https://climateaction100.wpcomstaging.com/progress-report/.

Chaudhry, Akif and Gavin Law. 2018. "New metrics for evaluating oil and gas portfolio resilience in a low-carbon future" Wood Mackenzie Report.

Colgan, Jeff D., Jessica F. Green, and Thomas N. Hale. 2021. "Asset Revaluation and the Existential Politics of Climate Change." *International Organization* 1–25. doi: 10.1017/S0020818320000296.

Delmas, Magali, Jinghui Lim, and Nicholas Nairn-Birch. 2015. Corporate Environmental Performance and Lobbying. *Academy of Management Discoveries* 2 (2): 175–197.

Dietz, Simon, Carlota Garcia-Manas, Dan Gardiner, William Irwin, Adam Matthews, Michal Nachmany, Rory Sullivan, and Faith Ward. 2018. *Carbon Performance Assessment in Oil and Gas*. London: Transition Pathway Initiative.

Dietz, Simon, Dan Gardiner, Valentin Jahn and Jolien Noels. 2020. *Carbon Performance of European Integrated Oil and Gas Companies.* London: Transition Pathway Initiative.

Energy and Climate Intelligence Unit. 2019. Countdown to zero. Available at https://ca1-eci.edcdn.com/reports/ECIU_Countdown_to_Net_Zero.pdf.

Ekwurzel, Brenda, Boneham, J., Dalton, M.W., Heede, R., Mera, R.J., Allen, M.R. and Frumhoff, P.C. 2017. "The rise in global atmospheric CO 2, surface temperature, and sea level from emissions traced to major carbon producers." *Climatic Change*, 144(4), pp.579-590.

Elvidge, C. D., Bazilian, M. D., Zhizhin, M., Ghosh, T., Baugh, K., & Hsu, F. C. (2018). The potential role of natural gas flaring in meeting greenhouse gas mitigation targets. *Energy Strategy Reviews*, 20, 156-162.

Fletcher, Luke, Tom Crocker, James Smyth, and Kane Marcell. 2018. *Beyond the Cycle: Which oil and gas companies are ready for the low-carbon transition?* Carbon Disclosure Project.

Garcia-Johnson, Ronie. 2000. *Exporting Environmentalism: US Multinational Chemical Corporations in Brazil and Mexico*. Cambridge, MA: MIT Press.

Geels, Frank W, David Tyfield, and John Urry. 2014. Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective. *Theory, Culture & Society* 31 (5): 21–40.
Geels, Frank W. 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy* 31 (8). NELSON + WINTER + 20: 1257–1274.
Green, Fergus, and Richard Denniss. 2018. Cutting with both arms of the scissors: the economic and political case for restrictive supply-side climate policies. *Climatic Change* 150 (1): 73–87.
Green, Jessica F. 2014. *Rethinking Private Authority: Agents and Entrepreneurs in Global Environmental Governance*. Princeton, NJ: Princeton.
Grumbach, Jacob M. 2015. Polluting industries as climate protagonists: cap and trade and the problem of business preferences. *Business and Politics* 17 (4): 633–659.
Gulbrandsen, Lars H. 2009. The emergence and effectiveness of the Marine Stewardship Council. *Marine Policy* 33 (4): 654–660.
Gupta, Joyeeta, Arthur Rempel and Hebe Verrest. 2020. "Access and Allocation: The Role of Large Shareholders and Investors in Leaving Fossil Fuels Underground." *International Environmental Agreements* 20: 303-322.
Hale, Thomas. 2016. "All Hands on Deck": The Paris Agreement and Nonstate Climate Action. *Global Environmental Politics* 16 (3): 12–22.
Halstead, Ted. 2020. "We Can't Slow Climate Change without the Energy Companies," *The New York Times*, January 9. https://www.nytimes.com/2020/01/09/opinion/renewable-energy-oil-companies.html. Accessed 21 October 2020.
Henriques, Irene, and Perry Sadorsky. 2011. "The Effect of Oil Price Volatility on Strategic Investment." *Energy Economics* 33(1):79–87. doi: 10.1016/j.eneco.2010.09.001.
Heede, Richard. 2014. "Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers, 1854–2010." *Climatic Change* 122(1-2): 229-241.
Hsueh, Lily. 2019. "Corporations at a Crossroads: How Multilevel Governance Interactions Shape Participation and Effort in Private Governance Regimes." *Governance* 32 (4): 715-760.
InfluenceMap, 2019. "Big Oil's Real Agenda on Climate Change" Available at https://influencemap.org/report/How-Big-Oil-Continues-to-Oppose-the-Paris-Agreement-38212275958aa21196dae3b76220bddc. Accessed 21 October 2020.
International Energy Agency. 2019. *World Energy Outlook 2019. Paris: International Energy Agency.* Available at <https://www.iea.org/reports/world-energy-outlook-2019/coal>. Accessed 7 February 2020.
Keohane, Robert Owen, and Helen V Milner. 1996. *Internationalization and Domestic Politics*. Cambridge University Press.
Levy, David L., and Ans Kolk. 2002. Strategic Responses to Global Climate Change: Conflicting Pressures on Multinationals in the Oil Industry. *Business and Politics* 4 (3): 275–300.
Lindblom, Charles E. "The Science of "Muddling Through"." *Public Administration Review* 19, no. 2 (1959): 79-88.
Locke, Richard M. 2013. *The Promise and limits of private power: promoting labor standards in a global economy*. Cambridge; New York: Cambridge University Press.
Mahdavi, Paasha. 2020. *Power Grab: Political Survival Through Extractive Resource Nationalization*. Cambridge, UK: Cambridge University Press.

Meadowcroft, James. 2009. What about the politics? Sustainable development, transition management, and long term energy transitions. *Policy Sciences* 42 (4): 323.
Meckling, Jonas. 2015. Oppose, Support, or Hedge? Distributional Effects, Regulatory Pressure, and Business Strategy in Environmental Politics. *Global Environmental Politics* 15 (2): 19-37.
Manley, David and Patrick Heller. 2020. Stranded National Oil Companies? Strategies for Companies and Their Owners Facing an Uncertain Energy Transition. *Natural Resources Governance Institute* working paper.
Mildenberger, Matto. 2020. *Carbon Captured: How Business and Labor Control Climate Politics*. Cambridge, MA: MIT Press.
Nasiritousi, Naghmeh. 2017. "Fossil fuel emitters and climate change: unpacking the governance activities of large oil and gas companies." *Environmental Politics* 26(4): 621-647.
Oil Change International. 2019. "Drilling Toward Disaster" Available at http://priceofoil.org/content/uploads/2019/01/Drilling-Towards-Disaster-Web-v3.pdf.
Pagliari, Stefano and Kevin L. Young. 2014. "Leveraged interests: Financial industry power and the role of private sector coalitions." *Review of International Political Economy*, 21:3, 575-610.
Pickl, Matthias J. 2019. "The renewable energy strategies of oil majors – From oil to energy?" *Energy Strategy Reviews* 26(100370): 1-8.
Prakash, Aseem, and Matthew Potoski. 2006. *The Voluntary Environmentalists: Green Clubs, ISO 14001, and Voluntary Environmental Regulations*. Cambridge: Cambridge University Press.
Prakash, Aseem. 2000. *Greening the Firm: The Politics of Corporate Environmentalism*. Cambridge, U.K. ; New York: Cambridge University Press.
Pulver, Simone. 2007. "Making Sense of Corporate Environmentalism: An environmental contestation approach to analyzing the causes and consequences of the climate change policy split in the oil industry." *Organization & Environment* 20(1):44-83.
Raval, Anjli. 2020. "New BP boss Bernard Looney pledges net zero carbon emissions by 2050." *Financial Times*. Available at https://www.ft.com/content/e1ee8ab4-4d89-11ea-95a0-43d18ec715f5. Accessed 21 October 2020.
Seto, Karen C., Steven J. Davis, Ronald B. Mitchell, Eleanor C. Stokes, Gregory Unruh, and Diana Ürge-Vorsatz. 2016. Carbon Lock-In: Types, Causes, and Policy Implications. *Annual Review of Environment and Resource*s 41 (1): 425–452.
Skjærseth, Jon Birger, Guri Bang, and Miranda A. Schreurs. 2013. Explaining Growing Climate Policy Differences Between the European Union and the United States. *Global Environmental Politics* 13 (4): 61–80.
Supran, Geoffrey, and Naomi Oreskes. 2017. "Assessing ExxonMobil's Climate Change Communications (1977–2014)." *Environmental Research Letters* 12(8):084019. doi: 10.1088/1748-9326/aa815f.
Unruh, Gregory C. 2000. Understanding carbon lock-in. *Energy Policy* 28 (12): 817–830.
van der Ven, Hamish. 2019. *Beyond Greenwash: Explaining Credibility in Transnational Eco-Labeling*. New York: Oxford University Press.
van der Ven, Hamish, Steven Bernstein, and Matthew Hoffmann. 2016. Valuing the Contributions of Nonstate and Subnational Actors to Climate Governance. *Global Environmental Politics* 17 (1): 1–20.

Victor, D.G., Geels, F.W. and Sharpe, S., 2019 *Accelerating the Low Carbon Transition: The Case for Stronger, More Targeted and Coordinated International Action*

Victor, D.G., Hults, D.R. and Thurber, M.C. 2011. *Oil and Governance: State-Owned Enterprises and the World Energy Supply*. Cambridge University Press.

Vogel, David. 2010. The Private Regulation of Global Corporate Conduct: Achievements and Limitations. *Business & Society* 49 (1): 68–87.

Vormedal, Irja, Lars H. Gulbrandsen, and Jon Birger Skjærseth. 2020. "Big Oil and Climate Regulation: Business as Usual or a Changing Business?" *Global Environmental Politics* 20(4):143–66. doi: 10.1162/glep_a_00565.

Appendix: Transition, Hedge, or Resist? Understanding Political and Economic Behavior toward Decarbonization in the Oil and Gas Industry

A1: Coding of business indicators

At the aggregate level, we measure firms' greenhouse gas emissions broadly (metric tons per thousand dollars of revenue) and specifically, firms' flaring of natural gas at extraction and processing sites (metric tons flared per million barrels of oil equivalent). These indicators reflect firm-wide behavior in reducing scope 1 and scope 2 emissions -- direct emissions of greenhouse gases from the firms' own sources and acquired or purchased sources. In terms of energy efficiency, we measure total energy consumed to generate each dollar of revenue (scaled as MWh per million dollars revenue).

We measure firms' commitment to oil production using production mix (oil production as % of total oil and gas production) and average production life of existing reserves (in years). Each indicator captures a different temporal aspect of business behavior. Fuel production mix reflects a firm's current commitment to relatively-carbon-intensive crude oil compared to natural gas. Firms with a higher share of oil in their fuel mix exhibit a strategy that does not deviate from the core fossil fuel business model (BAU). By contrast, firms with a lower share of oil (and thus more natural gas) in their fuel mix are reducing their emissions, reflecting a BAU disruption. While this lowers emissions intensity, it does have the potential to lock-in natural gas over the medium term. In other words, though a disruption, it is inconsistent with decarbonization. Our measure of average reserve life captures the compatibility of existing investments with long-term climate goals. A "high" average reserve life reflects an asset base that is dominated by conventional oil fields, locking in carbon emissions for 13 years and beyond. A "low" average reserve life reflects a changing asset base, which includes both conventional oil and unconventional oil and gas.

Renewables investments are measured using data on publicly-reported joint ventures, mergers & acquisitions, and equity investments from 2001 to 2019. Information is drawn primarily from Bloomberg Terminal and then verified using firm press releases, annual reports, and a variety of media sources, including Business Wire, Crunch Base, the Financial Times, the New York Times, PR News Wire, Tech Crunch, and Wind Power Monthly.

Finally, we note that our thresholds for "disruption" are based on our implicit assumption of what constitutes full decarbonization. While most oil companies and some international organizations are still forecasting increases in global oil demand, oil production will have to fall below 40 million barrels per day by 2040 to stay consistent with the Paris Accord targets.[22] Indeed, as of May 2021, the IEA projects oil companies must stop all new upstream oil and gas exploration by the end of 2021 to limit warming to 1.5 degrees.[23] We therefore code full disruption as an oil major shifting entirely away from upstream oil commitments and into renewables and limited decarbonized gas investments.

[22] SEI, IISD, ODI, E3G, and UNEP. (2020). *The Production Gap Report: 2020 Special Report*. http://productiongap.org/2020report

[23] International Energy Agency. (2021). *Net Zero by 2050: A Roadmap for the Global Energy Sector*. Paris: IEA Publications.

Table A1. Standardized endpoint values for business indicators

Activity	*Indicator*	*Units*	*BAU endpoint (-1)*	*Disruption endpoint (+1)*
Emissions	Total emissions	tons per thousand dollars revenue	>0.4	<0.1
	Flaring	tons per million barrels of oil equivalent	0.0072 (max. observed)	0
Energy efficiency	Energy efficiency	MWh per million dollars revenue	>1000	0
Upstream oil commitments	Reserve life	years	>13	<1
	Fuel mix	oil as percentage of total production	100	0
Core renewables & non-oil investments	Core investments	Number of investments	0	>0
Non-core renewables & non-oil investments	Non-core investments	Number of investments	0	>0

A2: Coding of Shareholder Calls

We code firms' political strategies across six indicators: (1) acceptance that fossil fuel use will ultimately end, (2) acceptance of climate science, (3) attitudes towards carbon pricing, (4) support for international agreements, (5) support for national laws, and (6) attitudes towards carbon capture and storage (CCS). These assess the extent to which firms publicly express commitment to, and urgency around, climate change to their shareholders.

The first two indicators offer insight into firm communication tactics regarding the extent to which petroleum is "part of the problem." The next three measure firm strategies towards carbon regulation in particular and climate regulations in general. The last indicator, support for CCS, is a bellwether for whether firms support the continued extraction of oil, albeit with reduced emissions, or if firms seek to undertake transformative and disruptive decarbonization.

To measure acceptance of climate science, for example, we first search the earnings calls for mentions of "climate change," "climate science," "global warming," or "greenhouse gas." We then code the valence of these mentions as either accepting, partially accepting, or rejecting climate science.

Consider the disparate cases of BP and ExxonMobil. In a February 2019 earnings call, BP's chief economist Spencer Dale responded to a shareholder question on energy system strategy:

> "I think your question goes to sort of the heart of the biggest theme we were trying to bring out in this year's energy outlook, and that big theme was the nature of what we describe as the dual challenge facing the energy system, the need for more energy as well as less carbon. Now the second part of the dual challenge, the need for less carbon, I think is well understood and appreciated around the world, where climate science is real. We need to see a significant fall in carbon emissions if we're going to stop the very pernicious impact that climate science -- global warming could have on our economy and our well-being."[24]

Contrast this with the response to a shareholder question about climate risk by ExxonMobil's CEO Rex Tillerson in May 2011:

> "There is a consensus that human activity without question contributes to [climate] risk, but there is also recognition that the complexities of climate science involve many elements that are still not well understood by the scientific community. And it is important if we are going to formulate policies around the human component of that challenge that we understand what is the impact of those policies [are] going to be. Are they going to produce a measurable benefit or are they not? And in order to do that, it means you have to understand other elements of the climate system that the science communities quite frankly struggles with still today. And so we continue to fund a number of activities to better help the scientific community hopefully better understand this very complicated climate system, [this] very elegant climate system that we enjoy on planet earth."[25]

[24] "BPPLC Energy Outlook and Statistical Review of World Energy (Q&A Session) - Final." 19 Feb 2019. Factiva ID: FNDW000020190220ef2j002s2

[25] "ExxonMobil Corp Shareholders Meeting - Final." 25 May 2011. Factiva ID: FNDW000020110609e75p002gx

In this case, BP is coded as *accepting* climate science, while ExxonMobil is coded as *rejecting* given it is sowing doubt in the "complexities" of climate science, consistent with analyses of the company's internal documents (Supran and Oreskes 2017). This coding is also consistent with a) the scientific consensus that we do in fact understand the causes of climate change (Oreskes 2004), and b) that given this overwhelming consensus, delay is tantamount to climate denial (Mann 2021).

Table A2 provides details on coding decisions for this and the five other indicators we track.

Table A2.

Indicator	*Coding question*	*Accept (1)*	*Neutral (0)*	*Reject (-1)*
National laws	Does company support key national laws and policies (e.g., CAFE, NDCs, RESD, Waxman-Markey)?	Supports regulating emissions, efficiency, or requiring clean energy standards	Would abide by regulations but does not actively support or oppose	Opposes regulating emissions, efficiency, or requiring clean energy standards
International agreements	Does company support international agreements (e.g. Kyoto Protocol, Paris Agreement)?	Supports agreements and commits to abiding by agreements	Accepts agreements in theory, but does not support joining	Rejects international climate agreements
Carbon pricing	Does company support carbon-pricing (as a concept)?	Supports any kind of emissions markets, trading, carbon pricing, or carbon taxation	Yes, but at low prices or with vague conditions	Opposes any kind of pricing, taxes, or emissions markets
Climate science	Does company accept climate science?	Climate change is real and is caused by human activity	Neither supports nor denies	Climate could be changing but not clear why; sowing any doubt in climate science
CCS	Does company support carbon capture and storage?	Company is pursuing CCS	"Someone" should pursue CCS	Company rejects CCS
End to fossil fuels	Does company accept there will be an end to burning fossil fuels?	Yes, sometime this century	Some vague point in the future	No

Table A3: InfluenceMap rankings of firm political behavior

Firm-Year	**IM_Grade** How "pro" or "con" climate policy A-B is pro, anything less is con	**IM_Lobby** Total lobbying spend, including via trade associations ($m)	**IM_Brand** How much spent on climate-related PR activities ($m)	**Carbon Policy Footprint** qualitative assessment of pro or con * intensity of engagement * political weight, Ranges from +100 to -100
BP 2017	-	-	-	-31
BP 2018	E+	53	30	-
BP 2019	D-	-	-	-47
Chevron 2017	-	-	-	-49
Chevron 2018	F	29	4	-
Chevron 2019	E-	-	-	-58
ConocoPhilips 2017	-	-	-	-28
ConocoPhilips 2019	E+	-	-	-29
ExxonMobil 2015	E-	27	-	-
ExxonMobil 2017	-	-	-	-52
ExxonMobil 2018	E	41	56	-
ExxonMobil 2019	E+	-	-	-48
Occidental 2017	-	-	-	-16
Occidental 2019	E+	-	-	-24
Shell 2015	D-	22	-	-
Shell 2017	-	-	-	-26
Shell 2018	D	49	55	-
Shell 2019	D+	-	-	-30
Total 2017	-	-	-	-31
Total 2018	D	29	52	-
Total 2019	D+	-	-	-25
ENI	-	-	-	-
Repsol	-	-	-	-
Statoil	-	-	-	-
Correlation coefficient with earnings call indicator measure (t-statistic in brackets)	0.52* [2.11]	0.48 [1.21]	0.83* [2.58]	0.12 [0.42]

Table A4: Descriptive Statistics

Summary Statistics	N	mean	min	max	std. dev
Overall Decarbonization	110	-0.99	-1.82	0.68	0.64
Political Decarbonization	110	-0.48	-1	1	0.62
Business Decarbonization	110	-0.51	-0.85	0.10	0.22
Emissions Regulation in HQ	110	75.69	71.19	83.95	4.251
Emissions Regulation in Market	107	74.48	71.19	83.95	4.348
Emissions Regulation in Production	72	72.42	71.19	77.49	2.511
R&D Expenditures (Percent)	72	2.58	0	6	1.59
Climate Resolutions	38	3.368	1	8	1.792
Coalition Membership (Sum)	110	1.564	0	3	0.904
Average Oil Price	110	78.1	43.42	103.27	22.62
Diversification (Percent)	107	52.12	18.63	87.38	19.32
Refining Capacity (log)	72	7.346	5.718	8.571	0.839

Table A5: Random Effects

	Model 5
Emissions Regulation in HQ	0.101***
	(0.030)
Diversification	0.004
	(0.005)
Refining (log)	-0.473**
	(0.185)
R&D	0.025
	(0.134)
Membership	0.461***
	(0.134)
Oil Price	0.003
	(0.004)
Constant	-6.655**
	(2.915)
$sigma_u$	.23015306
$sigma_e$	.47628157
rho	.18930548
Observations	63

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A6: Including Year as IV

	Model 6
Emissions Regulation in HQ	0.100***
	(0.027)
Diversification	0.005
	(0.004)
Refining (log)	-0.427**
	(0.177)
R&D	3.440
	(10.942)
Membership	0.371**
	(0.109)
Oil Price	0.005
	(0.004)
Year	0.048
	(0.038)
Constant	-102.831
	(74.878)
Observations	63
R-squared	0.623

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A7: Year Fixed Effects

	Model 7
Emissions Regulation in HQ	0.092**
	(0.029)
Diversification	0.005
	(0.004)
Refining (log)	-0.521***
	(0.149)
R&D	7.971
	(10.582)
Membership	0.417***
	(0.085)
Oil Price	-0.015
	(0.028)
2011.year	0.280
	(0.659)
2012.year	0.386
	(0.727)
2013.year	0.304
	(0.691)
2014.year	0.483
	(0.667)
2015.year	-0.676
	(0.733)
2016.year	-0.879
	(0.885)
2017.year	-0.152
	(0.658)
2018.year	-
Constant	-4.296
	(3.973)
Observations	63
R-squared	0.664

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A8: Alternative Measurement

	Model 1	Model 8	Model 9	Model 10
Emissions Regulation HQ	0.103***			
	(0.027)			
Diversification	0.004	-0.006	0.003	0.007
	(0.003)	(0.005)	(0.006)	(0.004)
Refining (log)	-0.459**	-0.816***	-0.865***	-0.563**
	(0.174)	(0.147)	(0.179)	(0.231)
R&D	0.028	0.154	0.204	0.141
	(0.116)	(0.096)	(0.110)	(0.137)
Membership	0.448***	0.849***	0.625***	0.223
	(0.107)	(0.096)	(0.164)	(0.213)
Oil Price	0.002	0.011**	0.007	0.001
	(0.004)	(0.003)	(0.004)	(0.004)
EU HQ		0.720***		
		(0.166)		
Natural Resource Dependence			-4.603	
			(3.089)	
EPI HQ				0.539*
				(0.250)
Constant	-6.899**	1.966*	2.957**	0.162
	(2.737)	(0.957)	(1.093)	(1.300)
Observations	63	63	63	35
R-squared	0.609	0.547	0.450	0.511

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A9: Membership Lagged

	Model 1	Model 11	Model 12	Model 13
Emissions Regulation HQ	0.103***	0.105***	0.099***	0.114***
	(0.027)	(0.025)	(0.028)	(0.026)
Diversification	0.004	0.005	0.003	0.003
	(0.003)	(0.004)	(0.004)	(0.004)
Refining (log)	-0.459**	-0.365*	-0.370*	-0.340
	(0.174)	(0.180)	(0.161)	(0.192)
R&D	0.028	0.009	0.037	0.016
	(0.116)	(0.106)	(0.106)	(0.108)
Membership	0.448***			
	(0.107)			
Oil Price	0.002	-0.002	-0.003	-0.004
	(0.004)	(0.003)	(0.002)	(0.003)
MembershipL1		0.350**		
		(0.133)		
MembershipL2			0.407**	
			(0.119)	
MembershipL3				0.340**
				(0.124)
Constant	-6.899**	-7.118**	-6.541*	-7.663**
	(2.737)	(2.723)	(2.857)	(2.995)
Observations	63	63	63	55
R-squared	0.609	0.616	0.649	0.600

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure A1. Renewable energy deals, top 10 major oil and gas firms, 2001-2019. *Figure shows the total number of clean energy deals across three types: direct investments, joint ventures, and mergers and acquisitions (M&A). Source: Bloomberg Terminal.*

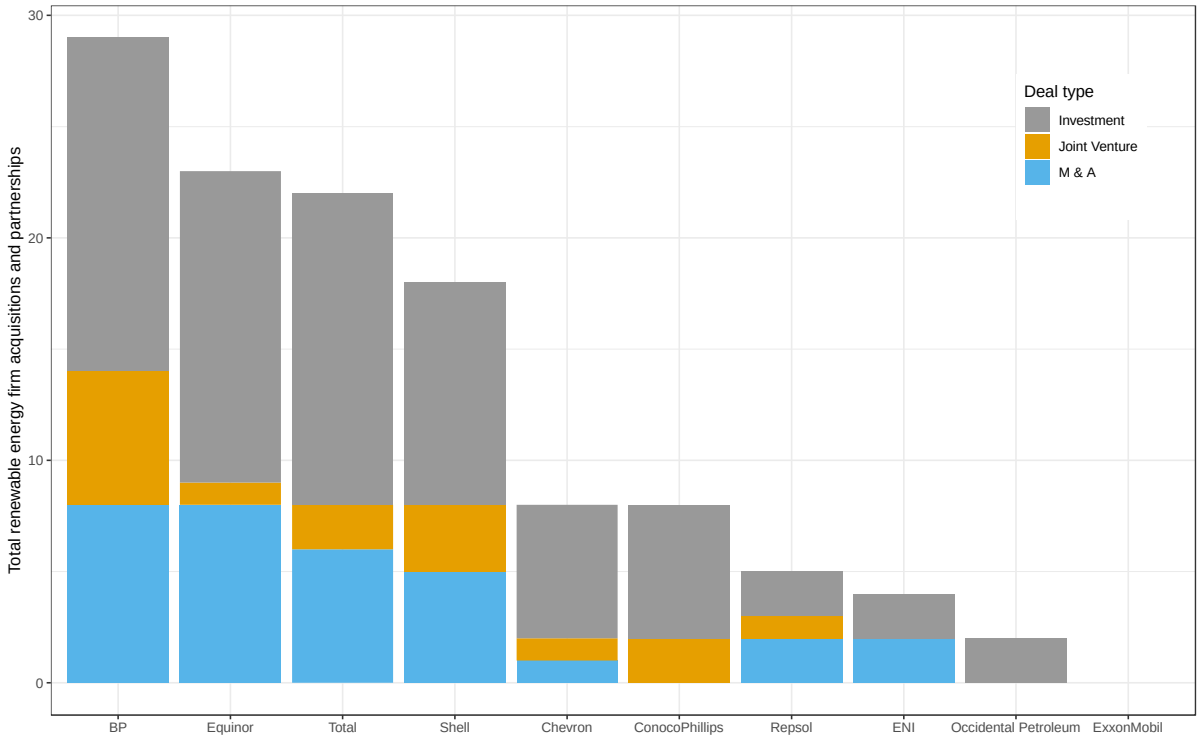

Figure A2: Emissions and energy efficiency trends, top 10 major oil and gas firms, 2005-2018. *Total greenhouse gas emissions in million metric tons (top left); greenhouse gas emissions efficiency in metric tons per thousand dollars revenue (top right); methane flaring in metric tons per million barrels of oil equivalent (bottom left); and energy efficiency of total firm operations in megawatt-hours per million dollars revenue (bottom right). Source: Bloomberg Terminal.*