Transition, Hedge, or Resist? Understanding Political and Economic Behavior toward Decarbonization in the Oil and Gas Industry[1]

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Abstract

Many oil and gas firms are making announcements about ambitious plans to go green. But are they actually walking the talk? 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. 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 indicates three main findings. First, we do not see any firms decarbonizing their operations or shifting away from fossil fuels during the time frame of our study. According to our conceptual framework, the most ambitious firms are engaging in *hedging* – mitigating risk through diversification rather than moving toward wholesale decarbonization. Observed changes in business behavior have been relatively modest in scope. Second, we do see the major oil and gas firms – generally speaking – improving along many political indicators we examine during the 2010-2018 period. In particular, many of the firms we examine have made strides in terms of adopting more pro-climate political behavior in the last decade. And third, we observe that firms that have progressed further 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.

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Introduction

Decarbonizing the economy requires overcoming the incentive of powerful economic actors – principally, those sectors that are fossil-fuel dependent—to maintain the status quo. This includes essentially all 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 most polities, and correspondingly, among the strongest barriers to more aggressive climate policies.

Amongst these sectors, the oil and gas industry stands out. It is one of the largest industries in the world economy, and, like finance, occupies a structural position of power since most other industries as well as consumers depend on its products. Moreover, unlike sectors for which fossil fuels are merely a critical input, the oil and gas business model is defined by the production of fossil fuels. This creates a potential existential crisis for the industry as it faces climate change and gives it a particularly strong incentive to resist decarbonization.[2] Yet, at the same time, a number of oil and gas firms have declared their ambition to become "net zero," or even to transition entirely away from their core businesses. Under what conditions should we expect oil and gas firms to resist decarbonization, and what might make them seek to transition?

While it is not possible to predict the future of the oil and gas industry, we aim to elucidate the political economy of oil and gas companies vis-a-vis decarbonization by conceptualizing firms as both political and economic actors, and by empirically evaluating their approaches to decarbonization in the decades before the pandemic shock that began in 2020. This approach contributes an analytic framework and empirical baseline to help observers assess future prospects for transition.

Conceptually, we develop a simple two dimensional framework that recognizes the dual role of firms as both economic and political actors. First, as economic actors, oil and gas firms' activities are primary sources of greenhouse gases. Recent analysis of historical emissions suggests that 63% of the global carbon dioxide and methane emitted into the atmosphere can be traced to a mere 90 oil and gas firms.[3] These "carbon majors" possess fossil fuel reserves that can, if produced and emitted, generate significant profits for investors while also intensifying global warming. Here we focus on a subset of these actors: large, publicly traded oil and gas companies.[4]

Second, as political actors, oil and gas firms have been amongst the most influential interest groups in the politics of major nations. According to one NGO report, the five largest oil majors have spent US $200 million per year lobbying against climate policy since the Paris Agreement, and about the same amount

[2] Colgan, Green and Hale forthcoming.
[3] Heede 2014, Ekwurzel et al. 2017.
[4] National oil companies, many of which are significantly state-owned or controlled, are also critical in this regard as they account for 43 percent of global capital expenditures in oil and gas. However, due to data limitations, heterogeneous measurement, and differing political pressures facing NOCs we restrict our focus to non-state-owned entities. See Heede 2014, Mahdavi 2020, Manley and Heller 2020.

annually on climate-related branding and public relations.[5] Yet at the same time, a number of companies have asserted that they can and must play a major role in addressing climate change.[6]

Following this two dimensional framework, 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. 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. 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? We then theorize explanations for our observed variation, and probe the plausibility of these explanations by identifying correlates of decarbonization behavior via statistical analysis. We do not make strong causal claims with regard to the determinants of decarbonization, but do identify intriguing relationships that could guide future research.

This analysis leads to three main findings. First, we do not see any firms decarbonizing their operations or shifting away from fossil fuels during the time frame of our study. According to our conceptual framework, the most ambitious firms are engaging in *hedging* – mitigating risk through diversification rather than moving toward wholesale decarbonization. Observed changes in business behavior have been relatively modest in scope. Second, we do see the major oil and gas firms – generally speaking – improving along many political indicators we examine during the 2010-2018 period. In particular, many of the firms we examine have made strides in terms of adopting more pro-climate political behavior in the last decade. And third, we observe that firms that have progressed further 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.

These findings contribute to existing literature in several ways. First, they build on a growing literature that treats firms as political actors making politically and ecologically relevant choices.[7] Much of the existing literature in this area examines either the political or (more commonly) business behavior of firms separately.[8] Our approach demonstrates the value of considering these dimensions in tandem to develop a more holistic view of firm behavior. Moreover, scholars of global governance have documented a growing trend towards voluntary governance initiatives by private actors, documenting how such efforts produce improvements in firm behavior in some instances but not others.[9] Our research suggests that while improvements in the oil and gas sector are associated with greater participation in such initiatives, the most significant changes are in terms of political, not business behavior. This adds nuance to existing studies, suggesting that participation in such settings may be less about business than politics.

While our findings focus on the oil and gas sector, we note that the analytic framework adopted here could be applied to other hard-to-abate sectors as well. For example, the airline industry faces similar

[5] InfluenceMap, "Big Oil's Real Agenda on Climate Change," March 2019
[6] Ted Halstead, "We Can't Slow Climate Change without the Energy Companies," *The New York Times*, January 9, 2020.
[7] Prakash 2000, Pulver 2007.
[8] Caldecott et al 2018, Chaudhry and Law 2018, Dietz et al 2018, Fletcher et al 2018, Nasiritousi 2017, Pickl 2019.
[9] E.g., Hsueh 2019, Potoski and Prakash 2006, Vogel 2010.

existential challenges as the oil and gas sector, and we would predict similar variation in firm response. That said, our focus on large, publicly traded oil and gas companies creates important scope conditions. For example, we may expect our findings to apply less well to national oil companies with high degrees of state ownership, whose decisions may follow logics driven by political rather than financial pressures.[10] We comment on the generalizability of the theoretical argument in the conclusion.

1. Navigating the Decarbonization Dilemma

Climate policy can pose an existential threat to a firm that has built its entire asset portfolio, personnel, infrastructure and reputation around fossil fuels. At the same time, firms are under growing pressure from investors, activists, and regulators to address the implications of their actions for climate change. Firms have a wide variety of potential responses to this pressure, ranging from business as usual to complete transition to fossil free energy production. This section explores the dimensions of this decarbonization dilemma in greater detail.

Our approach builds on a diverse set of literatures which examine firm behavior, their role in pathways to decarbonization, and socio-technical transitions more broadly. There is a vast technical literature which evaluates policy scenarios and how they could contribute to decarbonization. Because we take firms as the unit of analysis, we focus instead on what we know about the behavior of individual firms vis-à-vis decarbonization and the processes that spur socio-technical transitions.

Climate Change as an Existential Problem

Achieving substantial action on climate mitigation will require moving away from fossil fuels. As a result, it is unsurprising that an oil and gas firm invest significantly in opposing 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.[11] Similarly, Robert Brulle estimates sectors affected by proposed climate legislation spent over $2 billion lobbying the US Congress between 2000-2016.[12] These data are consistent with political economy approaches that highlight the ways firms push for public policies that advance their commercial interests.[13]

Serious decarbonization poses an existential crisis to these firms: fundamentally, they must change their business model (no longer be "oil and gas" firms) or go out of business. As these threats become more immediate, existing research tells us to expect that firms will fight harder to preserve the status quo – and the rents they extract from it.[14] This logic is consistent with research by Breetz and colleagues who 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, since they do not see any immediate threats. However, as these technologies diffuse and are more widely

[10] Victor et al. 2012; Manley and Heller 2020.
[11] InfluenceMap, March 2019.
[12] Brulle 2018.
[13] Keohane and Milner 1996.
[14] Colgan, Green and Hale 2020.

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.[15] Oil and gas firms may thus similarly feel the need to fight harder as fuel alternatives become more appealing. However, the simple observation that firms will resist policies that threaten their profits tells us little about how firms in the same industry might vary, or how the same firm might vary over time.

Growing External Pressure

During the time frame of our study, oil and gas firms faced growing external pressure to decarbonize. There are three notable changes in the broader political opportunity structure which may affect the decision-making of firms. Variation in these pressures, both across firms and across 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 now have flaring bans or policies in place to regulate flaring.[16] More dangerously for oil and gas companies, 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[17], suggesting that oil and gas will no longer be a major part of their energy mix.

Second, international cooperation on climate change was re-invigorated in the mid-2010s, culminating in the Paris Agreement in 2015.[18] In the run up to the Paris Agreement, states created the Non-State Actor Zone for Climate Action (NAZCA). NAZCA invited voluntary commitments from non-state and sub-state actors and was subsequently institutionalized in the Paris Agreement. The shift to voluntarism provided ample leeway for emissions intensive industries to define their own commitments, including oil and gas, while also pressuring these actors to contribute in some way. Such voluntary efforts are increasingly integrated into the broader climate regime, which has sought to catalyze voluntary actions from firms and other sub- and non-state actors. [19]

Third, firms faced growing pressure from activists and stakeholders seeking to hold them accountable for their negative effects on the climate. There has been a spate of lawsuits in the last several years, primarily targeting fossil fuel companies and governments for failing to protect the citizens from climate change – either through deliberate action or lack of action. Increasing activism at a number of pipelines aims to frustrate development of more fossil infrastructure. The divestment campaign seeks remove much needed capital from fossil fuel companies. And there has been growth in shareholder activism. Our research shows a marked increase in the number of shareholder resolutions around climate change among the oil majors. Using data collected by EthVest, we coded the number of shareholder resolutions related to climate change from 1993-2019. These include resolutions for oil companies Anglo American, BP,

[15] Breetz, Mildenberger, and Stokes 2018.
[16] Elvidge et al. 2018.
[17] Energy and Climate Intelligence Unit 2019.
[18] Falkner 2016.
[19] Hale 2016.

Chevron, Conoco, CONSOL, Exxon and Shell. We 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 which suggests that firms can "do well by doing good" – curbing negative externalities such as environmental degradation or unsafe labor conditions can also be good for a firm's bottom line. This is the logic of numerous voluntary regulatory initiatives, such as the United Nations Global Compact, the Forest Stewardship Council, or, in climate change, the Science-based Targets Initiative. The literature on such initiatives provides a nuanced analysis of whether firms' self-regulation can be an effective change agent.[20] 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.[21] 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."[22] Research on the Marine Stewardship Council suggests that uptake has been quite widespread in the developed world, but much more limited in the developing world, where there are large and lucrative fish markets.[23]

That said, voluntary action that produces short term environmental action can have ambivalent or even negative effects on long-term decarbonization. This trend can be seen in the creation of the Carbon Pricing Leadership Coalition (CPLC) in the US, launched at the Paris negotiations in 2015. The CPLC describes itself as "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.[24] 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, a seat at the table ensures the ability to influence the outcome. And second, carbon pricing is a means to ensure the continued competitiveness of natural gas. They note, "to the extent that carbon pricing will make gas more competitive and squeeze coal out of the power sector, majors can benefit financially from the adoption of a regulation that establishes a significant price on coal."[25] Thus, the increasing acceptance of carbon pricing among oil majors appears to be beneficial to the bottom line, though at the same time slows decarbonization efforts by locking in gas.

A Potential for Transformative Action?

[20] Cashore, Auld, and Newsom 2004; Garcia-Johnson 2000; Prakash 2000; Prakash and Potoski 2006; Green 2014; Ven 2019.
[21] Locke 2013.
[22] Cashore, Auld, and Newsom 2004.
[23] Gulbrandsen 2009.
[24] https://www.carbonpricingleadership.org/
[25] Vormedal et al. 2019, p. 21.

As the previous example illustrates, measuring immediate reductions in GHG emissions is but one way to evaluate firms' efforts to decarbonize. 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 (CO2e) out of the atmosphere."[26] Rather, it is about disrupting "carbon lock-in" – persistent market and policy failures that occur through interactions between "technological systems and governing institutions."[27] In this view, decarbonization requires understanding how economic, social and political systems produce market failures that constrain the adoption of carbon-friendly technologies.[28]

Have we observed any efforts by firms to catalyze systemic transformations in the oil and gas industry? 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.[29] 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.[30] 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, which indicate a move toward leadership in climate governance and enhance firms' capacity to undertake meaningful action in the future..[31]

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

The existential challenge of climate change for oil and gas firms creates incentives for firms to begin the process of shifting their business models, but also gives them increased interest in shaping the speed and direction of climate policies. At the same time, 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. 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). We are interested both in firms' absolute position on these dimensions (how close they are to transition or how strongly they resist it) as well as their position relative to other firms (are they leaders, laggards, or somewhere in the middle). We consider each dimension in turn.

[26] van der Ven, Bernstein, and Hoffmann 2016, 5.
[27] Unruh 2000, 817.
[28] Unruh 2000; Seto et al. 2016.
[29] https://oilandgasclimateinitiative.com/our-members/#impact
[30] Ibid.
[31] Bach 2019. This is consistent with earlier arguments by Prakash 2000, that internal management practices are critical to greening firms.

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. We describe the spectrum of political behavior by identifying four ideal points along it:

- **Strong (costly) effort against pro-climate policies**. At the far end of the spectrum, firms invest significant sums in lobbying against pro-climate policies both individually and via industry organizations. Their public statements express skepticism and/or lack of urgency around climate science. Decarbonization policies are always opposed.
- **Weak lobbying effort against pro-climate policies.** Weak opponents publicly accept climate science and the need for climate policy, but argue for weak or flexible regulations, actively oppose more stringent regulations, and never lobby directly in support of policies that would promote decarbonization. They may prefer to let industry groups, such as the American Petroleum Institute, argue most strongly against decarbonization and free-ride on other firms.
- **Weak lobbying effort supporting pro-climate policies.** Weak proponents publicly support decarbonization efforts and promote mild measures that push in the direction of decarbonization while continuing to offer firms significant flexibility (e.g. Risk disclosure obligations, long-term targets, low carbon prices). Firms may decide to leave or become inactive in less progressive industry groups.
- **Strong (costly) lobbying effort supporting pro-climate policies.** Strong proponents publicly recognize the urgency of decarbonization and support policies that promote a full transition away from fossil fuels. They expend resources influencing policymakers to support this transition. They reject or actively seek to change less progressive industry groups.

Business behavior

We define business behavior as firms' activities to seek profit in the market. These include, centrally, producing and selling products, but also ancillary activities like research and development and market strategy. Again, we describe variation in the business behavior dimension by identifying four ideal types along the spectrum.

- **Business as usual**. Firms make no effort to reduce GHG emissions. They have few investments in renewables and significant investments in upstream fossil fuels with long payback periods (and therefore greater carbon lock-in). They also have significant emissions of byproducts and low energy efficiency.
- **Melioration of business as usual.** Firms reduce emissions relative to total output but do not fundamentally change their business model. There are low investments outside of fossil fuels, as well as efforts to tackle gas leakage or flaring. Investment in gas may rise.
- **Limited disruption.** Firms continue investing in fossil fuels, but also make non-trivial moves into non-fossil business models. Fossil fuel assets shift from longer-term to shorter-term, and from upstream to downstream (e.g., plastics and petrochemicals).
- **Significant disruption.** Firms significantly reduce fossil fuel investment and increase investment in alternatives.

Combining business and political behavior

We expect a firm's political and business behaviors to be correlated, but not necessarily perfectly so. Logically, there are three ideal type strategies firms facing decarbonization can choose,[32] as represented in Figure 1:

1. **Transition** – political and market behavior both push toward decarbonization, and do so relatively strongly compared to other firms
2. **Hedge** – political and market behavior may push in different directions, and do so similarly to other firms
3. **Resist** - political and market behavior both push against decarbonization, and do so relatively strongly compared to other firms

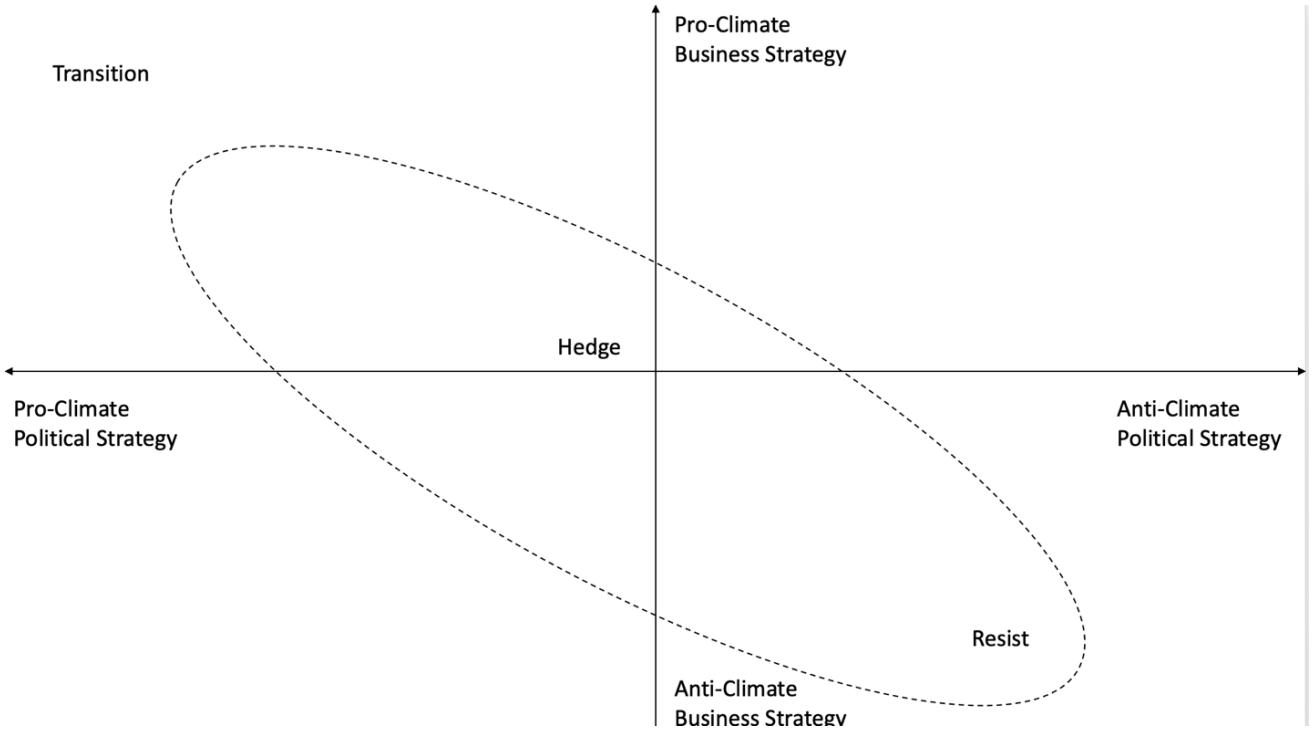

Figure 1. Ideal types of decarbonization strategies of oil and gas firms. *The y-axis represents the spectrum of firm strategy within business and operations; the x-axis represents the spectrum of firm strategy within policy. The dotted oval represents our expectation for the strategy of most firms.*

[32] This is similar to Meckling 2015, though he focuses specifically on firm responses to the EU-ETS..

3. Theoretical expectations

How can we explain variation in firms' political and business behavior? We treat firms as unitary,[33] profit-seeking actors that respond to both the market conditions and the political opportunity structures they face. Specifically, we highlight three categories of factors that affect firms' strategies and ultimately behavior:

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

We also note that firms' respond to the behavior of other market actors, but we do not address these dynamic interactions here. We explain the causal logic of specific variables in each of these categories in section 5 below, which examines correlates of firm behavior. Importantly, all of these categories of factors are partially endogenous. Over time, 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 some steps toward satisfying their demands. We should therefore understand firms' political and business behavior as a moving equilibrium shaped by these different factors. Moreover, firms may vary significantly not just in their present assets and characteristics, and policy environments, and position vis-a-vis others in the market, 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, we feel that it captures the dynamic political nature of decarbonization.

Because firms exist in a relatively competitive, though quasi-oligopolistic market, we expect most firms to be hedgers, and few to be transitioners or resisters. As noted above, firm behavior is partially shaped by the behavior of other market actors. This creates a centrifugal tendency, since firms are broadly pursuing the same business model. On average, firms that differ too much from their peers will likely lose market share and investment to competitors. Moreover, we expect these three categories of factors to reinforce themselves over time. A firm that moves into resistance may find it more 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 itself 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 those firms most likely to be 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 those policies in the future, either because of their own limitations or because

[33] In certain cases we can gain additional analytic traction by relaxing this assumption, as explored below.

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 new business models 4. Depend 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. Are 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. This includes BP, Chevron, ConocoPhillips, ENI, Equinor (formerly Statoil), ExxonMobil, Occidental Petroleum, Repsol, Royal Dutch Shell, and Total. Our present analysis covers the years of 2008-2019.

A number of policy and finance-related reports have sought to map variation in either the business behavior dimension or the political dimension of oil and gas companies.[34] Our analysis departs from these works by introducingan original measure of firms' political behavior, coding their speech on quarterly earnings calls to investors. This new measure provides more detail about different aspects of firms' political stances while also creating more comparable measures across a wider sample than previous approaches. Moreover, noting the interactions between the business and political dimensions, we put them into the same theoretical and empirical framework, creating a new systematic and robust measure of the extent to which firms are taking decarbonization seriously, or not. Second, many of the existing mappings look only at a single cross-sectional snapshot, while our approach allows us to track firm behavior over time.

[34] Caldecott et al 2018, Chaudhry and Law 2018, Dietz et al 2018, Fletcher et al 2018, Nasiritousi 2017, Pickl 2019

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 spending by oil and gas firms, predominantly in the United States.[35] The most systematic publicly available measures have been created by the NGO InfluenceMap (see table in appendix). This approach provides a very useful look at firms' behavior and, critically, captures "actions" (spending) as well as speech. At the same time, the InfluenceMap data has significant limitations, including a geographic focus on the United States and an inconsistent methodology year-to-year.

For this paper we developed a measure of political behavior that allows us to better describe the full range of variation: firms' speech in shareholder meetings ("earnings calls") 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. 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.

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 four key indicators: acceptance/denial of climate science, support for international agreements, attitudes towards carbon pricing, and acceptance that fossil fuel use will ultimately end. Each of these indicators assesses the degree to which firms' public statements express commitment to, and urgency around, climate change. 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 coded the valence of these mentions as either accepting, partially accepting, or rejecting climate science, according to a codebook developed by the researchers.

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."[36]

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

[35] Delmas, Lim, and Nairn-Birch 2015; Grumbach 2015.
[36] "BPPLC Energy Outlook and Statistical Review of World Energy (Q&A Session) - Final." 19 Feb 2019. Factiva ID: FNDW000020190220ef2j002s2

> "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."[37]

In this case, BP is coded as "accepting" climate science, while ExxonMobil is coded as "rejecting" climate science. These instances are then aggregated at the firm-quarter level and assigned a score ranging from -1 (fully rejecting climate science) to +1 (fully supporting climate science). Further details on coding decisions for this indicator and all other indicators are listed in the Appendix.

Measuring firms' climate-related business behavior

Many studies analyze firms' current plans for decarbonization. At the time of writing, current reports suggest little commitment to decarbonization. Climate Action 100+ notes that of 39 oil and gas companies, 24 have set long-term quantitative targets for reducing GHG emissions.[38] But none of these companies is committed to an absolute CO2 reduction target that includes scope 3 emissions – indirect emissions generated throughout the value chain of a given firm.

Even more revealing, only ENI has committed to an absolute CO2 reduction target at any emissions scope (only at scope 1 – a firm's direct emissions).[39] Only one out of 50 oil and gas companies in the London School of Economics' Transition Pathway Initiative's (TPI) most recent analysis had made a net zero commitment – again ENI, and again not including scope 3 emissions or indeed even all of scope 1 emissions.[40] BP has recently announced ambitions to reach net zero, but has yet to provide detail about how this would be achieved.[41]

By contrast, a number of firms have committed to less stringent carbon intensity targets. Shell, Repsol and Total have set intensity reduction targets applying to emissions across all three scopes, while ConocoPhillips, Occidental, BP, ENI and Equinor have set or committed to set some kind of intensity reduction target excluding scope 3 emissions. Meanwhile, all firms are planning significant expansion of oil and gas assets, totalling some USD$1.4 trillion in the period 2020-2024.[42] This is both intuitively and empirically inconsistent with meeting the Paris goal of limiting warming to 1.5 degrees Celsius.[43]

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[37] "ExxonMobil Corp Shareholders Meeting - Final." 25 May 2011. Factiva ID: FNDW000020110609e75p002gx
[38] Climate Action 100+, Sept. 2019, pp 21-26.
[39] Dietz et al. 2018, p. 5, p. 16.
[40] Ibid., pp. 25-27.
[41] Anjli Raval, "New BP boss Bernard Looney pledges net zero carbon emissions by 2050." *Financial Times,* 12 Feb 2020.
[42] Oil Change International 2019
[43] Carbon Tracker 2019

While analyzing plans can be useful, not least 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, here we focus on firm behavior in the past, not stated intentions about the future. On the business dimension, we focus on four different activities to construct an overall picture of firms' decarbonization efforts in the oil and gas sector: emissions, energy efficiency, upstream oil commitments, and renewables and non-oil investments.

At the aggregate level, we measure firms' greenhouse gas emissions broadly (metric tons per thousand dollars of revenue) and more 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 use a measure of total energy consumed to generate each dollar of revenue (scaled as MWh per million dollars revenue).

We measure firms' commitment to oil production using two indicators: production mix (oil production as a percent of total oil and gas production) and the average production life of existing reserves (in years). Each indicator captures a different temporal aspect of business behavior. A firm's fuel production mix reflects its current commitment to relatively-carbon-intensive crude oil compared to natural gas. Firms with a higher share of oil in their fuel mix reflect a strategy that does not deviate from the core fossil fuel business model ("business as usual," or "BAU"). By contrast, firms with a lower share of oil in their fuel mix are reducing their scope 3 emissions; this reflects a BAU disruption.[44] While this is forward progress in terms of emissions intensity, it does have the potential to lock-in natural gas over the medium term. In other words, while a disruption, it is not consistent with decarbonization.

Second, 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, one that includes both conventional oil and unconventional oil and gas.

We also 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 for this draft we are cautious to make strong descriptive inferences about differences in investment values across firms.[45] We group

[44] We also looked at purchases of gas reserves. Firms purchasing significant natural gas reserves signal a future commitment to deviating from BAU, while firms making limited or no purchases of gas reserves signal a future commitment to maintaining BAU.

[45] We examine differences in the types of investment instruments across firms, which we report in Appendix Figure 1.

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.[46]

This "core" v. "non-core" distinction allows us to evaluate the extent to which firms remain committed to fossil fuels and fossil-fuel infrastructure in a decarbonized system. For example, a firm investing heavily in carbon capture and storage (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 to business model (+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 2015-2018. Table A1 in the Appendix provides the full coding rules for each indicator.

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.[47] The results for each firm in our sample are presented in Figure 2. Overall, we find little evidence of 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 accept 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 changes in the future.

The top panel shows average political and business activities for the 2008-2014 period while the bottom panel shows the post-2014 averages.[48] 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.[49]

[46] 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.
[47] There are several alternatives to using averages for dimensionality reduction, ranging from principal components and factor analysis to latent space and measurement models. For now, 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.
[48] While we have data on business activities from 1998, we do not have information on earnings calls prior to 2006.
[49] Average oil prices from the *BP statistical review of energy* using Brent spot crude price.

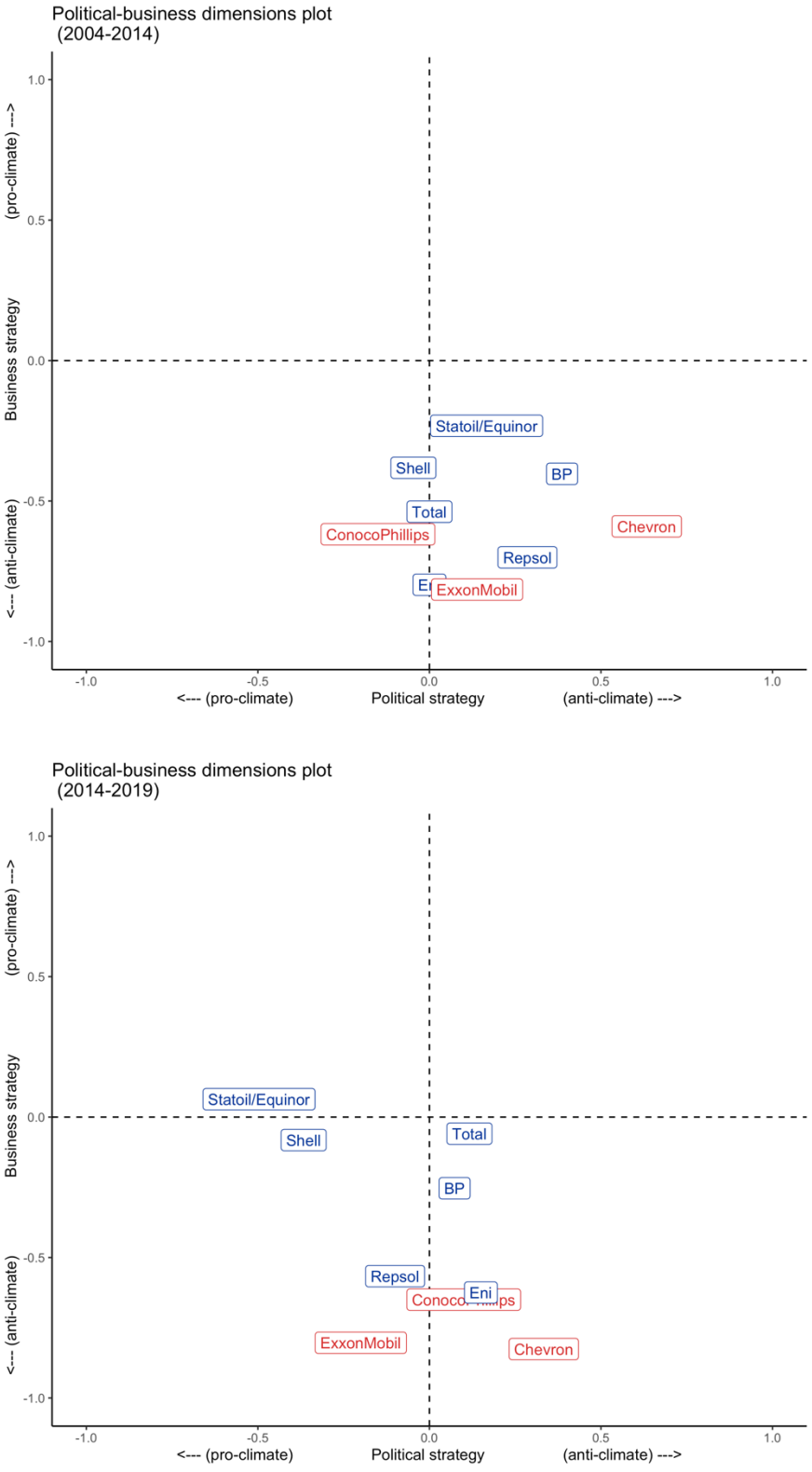


Figure 2. Variation in firm decarbonization activities in the oil and gas sector, 2008-19.

Figure 2 demonstrates that oil and gas firms have made negligible progress on decarbonization. No firm in the sample is pursuing a strategy towards a decarbonized transition; firms are instead either hedging or resisting the transition. Hedgers include those in the middle of the plots: this comprises Equinor, Shell, BP, and Total. Resisters include the remaining firms, located in the bottom right of the quadrant: Chevron, ConocoPhillips, ENI, ExxonMobil, and Occidental Petroleum.

Consistent with our expectations, the overall pattern in the post-2014 period (see Figure 3) 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, firms like Equinor and Total, that are the most pro-climate politically pursue the most pro-climate -- or, more accurately, the least anti-climate -- business strategies.

Two exceptions stand out from the pack. As indicated in the bottom panel of Figure 3, BP is among the most pro-climate firms politically, especially in the post-2014 period, but lags behind Equinor, Shell, and Total in terms of pro-climate business activities. By contrast, Occidental is the most anti-climate firm along the business dimension, but is fairly centrist in its political strategy. Overall, however, all firms fall within our expected range in Figure 1, especially in the post 2014 period.

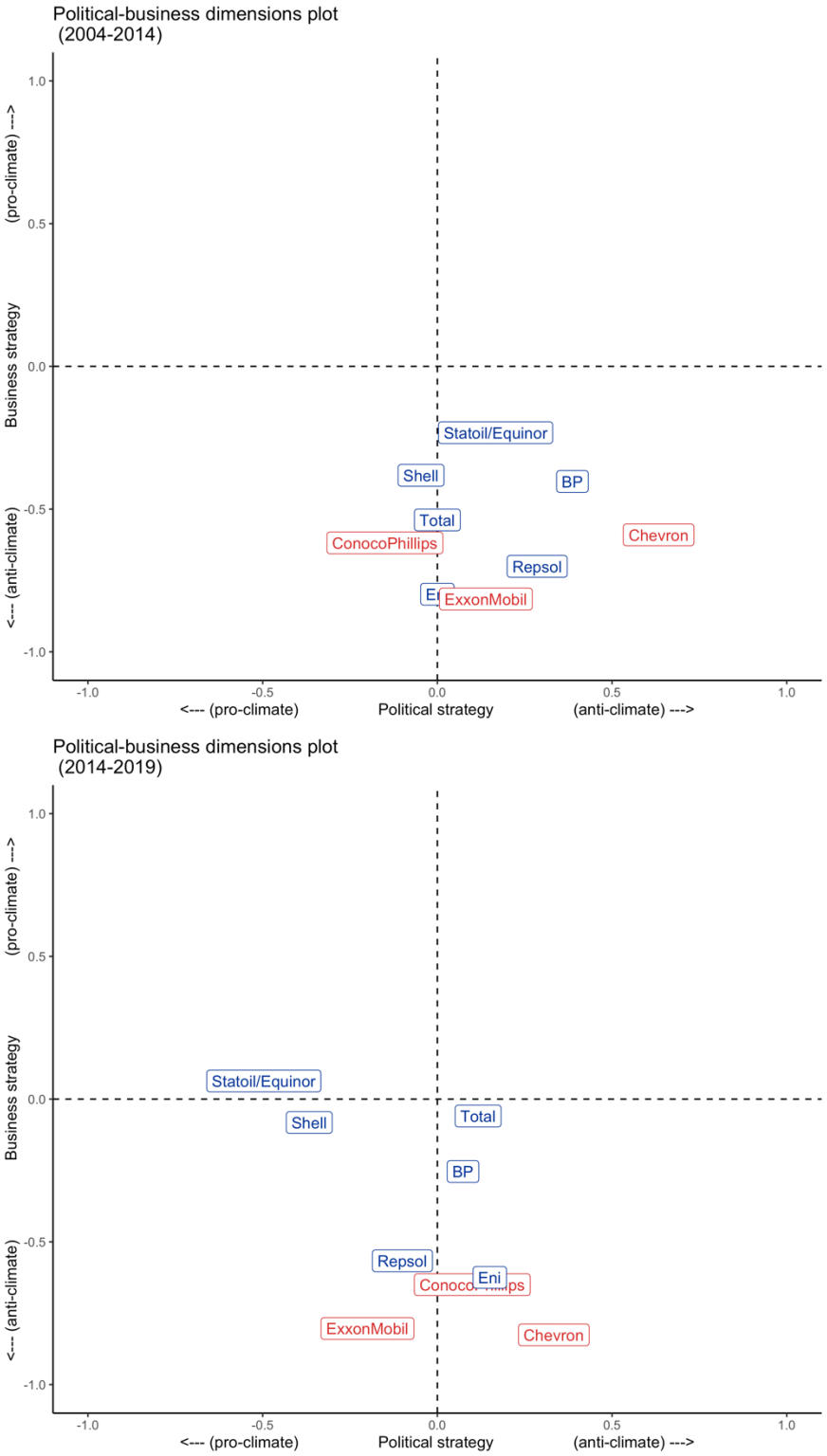


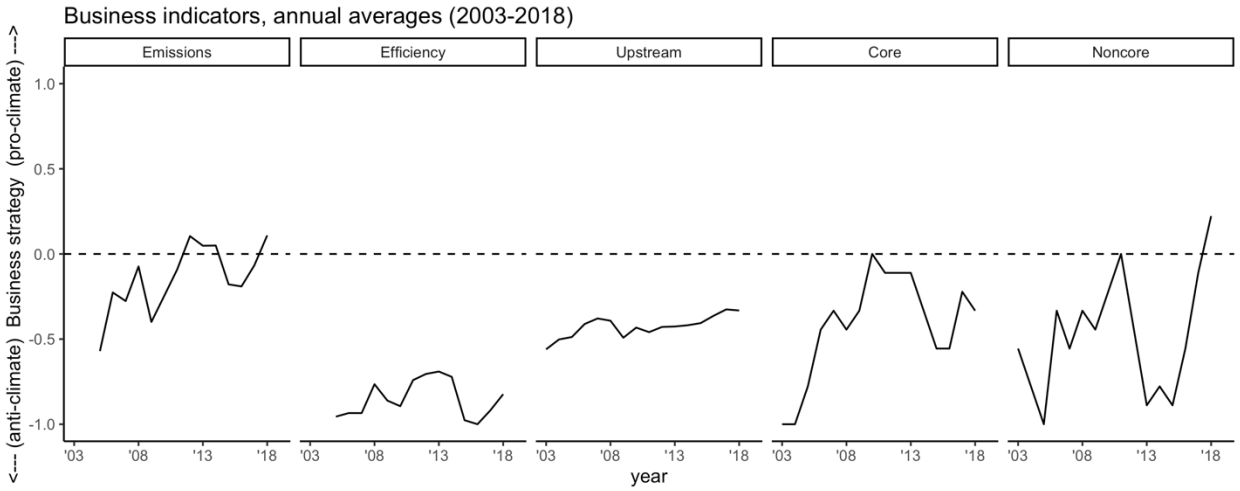
Figure 3. Variation in firm decarbonization activities in the oil and gas sector, pre- and post-2014.
Firms in red are based in North America; firms in blue are headquartered in Europe.

Business model variation

We find remarkably little within-firm temporal variation along the business dimension (comparing the top and bottom panels of Figure 3). This reflects a broader systemwide pattern of limited changes to the business model of the major oil firms along our indicators (Figure 3). Despite declining overall greenhouse gas emissions across firms, firm emissions have remained flat over time on a per dollar basis. There is progress on eliminating flaring, but no firm in the sample has yet achieved zero flaring targets espoused by the World Bank's Global Gas Flaring Reduction Partnership -- in which 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, there are no firms completely withdrawing from crude oil production and, aside from Repsol, the plurality of production across firms is still oil. There are similarly modest reductions in average reserve life. This has decreased for most firms, with the exception of ExxonMobil and BP, whose 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.[50]

Investments in renewables and non-oil activities that do not stray far from the core skill set of oil and gas firms -- such as offshore wind, biofuels, and gas power plants represents 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 this figure 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 ismarked increase in 2017-18, largely because of an uptick in solar investments by BP, Equinor, Repsol, Shell, and Total.



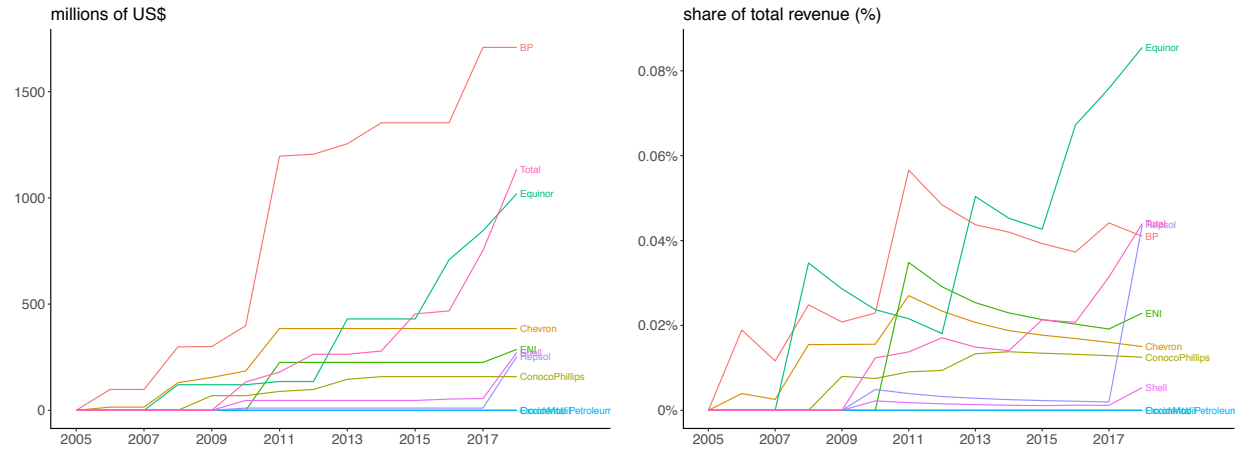
[50] Seto et al. 2016.

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). See Appendix Table 1 for corresponding endpoint values for each indicator.*

Separately, we also consider the *value* of firm investments in renewable energy projects, with the previously stated caveat of incomplete information for 41% of investments. Further, we do not yet have a proper denominator to track the relative importance of renewables to the overall investment portfolio of each firm; instead, we currently proxy for total investments using total revenues. With that said, we do not expect our patterns to significantly differ, given that investment growth largely tracks total revenue growth.

We find that while some firms have made progress in renewables investments over this period – namely, Equinor, Total, and Repsol – these improvements still 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 4). This is further evidence that no firm has committed to a decarbonization energy system at any meaningful level, perhaps sobering optimism about the potential for voluntary initiatives to trigger transformative change via this mechanism.

In addition, several firms have not kept pace in renewables investments over time. These firms, shown with downward sloping cumulative shares in Figure 5 (right panel), had made renewables investments in the early-2000s. However, these investments have either stopped entirely or diminished in value since the post-global-recession increase in oil prices starting in 2009. Between 2010 and 2018, for example, neither ExxonMobil, Chevron, or ConocoPhillips made any significant investments in renewable energy projects.[51] Overall, these patterns reflect the same 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 firms.



[51] While Shell ranks low in our cumulative share figure, this is due to missingness in the renewable energy deal value measure. In terms of frequency, Shell made 18 total investments into renewables companies during the 2005-2019 period, which ranks third among all firms in our sample (behind only Equinor and Total).

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 – no firm in our sample has made significant progress away from the core fossil fuel business model.

Political variation

By contrast, we find significant variation in firms' political decarbonization strategies over time. In the 2008-2014 period, nearly all firms adopted anti-climate public-facing rhetoric (Figure 3, bottom left panel). With the exceptions of ExxonMobil and BP, there is a clear shift among oil and gas firms towards more a pro-climate political strategy in the post-2014 period (Figure 3, bottom right panel). That said, there is no firm that unequivocally adopts a pro-climate political strategy, but rather there is clustering within the middle -- such that firms are either adopting "soft opposition" to climate policy or "soft support" for climate policy in the 2014-2019 period.

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

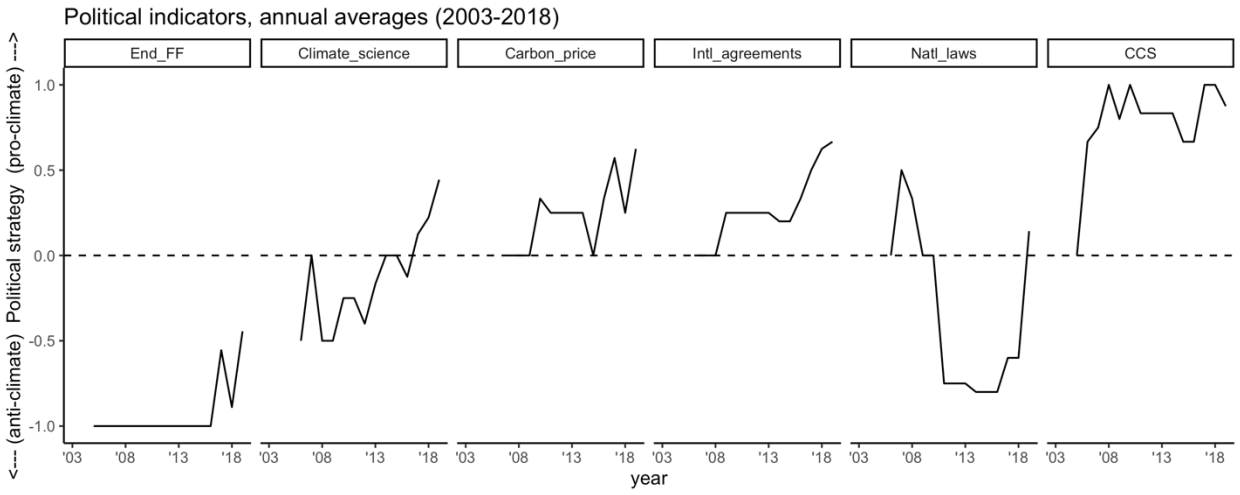


Figure 6. Firm political strategy, by indicator. *Each indicator is standardized to a scale running from strong effort against climate policy (-1) to strong support for climate policy (+1). See Appendix Table A9 for unscaled endpoint values for each indicator.*

At the indicator level, we find that much of the shift in firms' political strategies is concentrated in a decreased effort to deny climate science and a growing acceptance to the implementation of a carbon

price (Figure 5). 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 2013. Here there is a clear split between pro-agreement European firms (BP, ENI, Shell, Equinor, Repsol, and Total) and anti-agreement American firms (ExxonMobil, ConocoPhillips, and Occidental Petroleum), with Chevron as the lone American firm in support of an international climate agreement. These shifts are explicable in terms of broader political context: the voluntary nature of Paris and NAZCA meant that 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 remain steadfast over time in denying the end of fossil fuels. 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 future fossil-free energy system.

6. Exploring the Correlates of Decarbonization

To assess our theoretical framework, we also incorporate our data on firm characteristics and opportunity structures. 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. We expect that 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. We focused our original data collection on the decarbonization behavior of the 10 largest firms in the years 2008 to 2018.[52] Table 2 contains information about the measurement and data sources for the variables used in the analysis, and their descriptives can be found in the appendix. Notably, we were not able to collect attribute data from the firm Occidental due to non-reporting and encountered significant missing data from other firms prior to 2010, limiting our sample size for this analysis.

For this analysis, 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 the business and political dimensions of decarbonization (*overall decarbonization)*. It is important to note that though the dependent variable ranges from transition to resist, as set forth in Figure 1, in practice, the best performing firms only move as far as hedging. As explanatory variables, we include core firm attributes, attributes of the jurisdictions in which they operate, membership in climate coalitions, and time

[52] While we have data on business and political decarbonization strategies across the 2008-2019 period, we were unable to compile a complete dataset for our covariates for 2019.

varying trends in oil prices. All our models include robust standard errors to account for clustering by firm.

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 the *overall decarbonization* dependent variable 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.[53]

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 positive and significantly associated with *overall decarbonization*, suggesting that firms headquartered in jurisdictions

[53] 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.

with more stringent regulations are more likely to decarbonize. Similarly, the effect of emissions regulation in the main market for a firm 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. We also observe that the size of the refining sector in a firm (recall, larger refining operations imply less ability to shift 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 of decarbonization 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, but that 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 Combined DV	Model 2 Combined DV	Model 3 Political DV	Model 4 Business DV
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 conducted several additional analyses to assess the robustness of these findings, which we report in the appendix. To summarize, the results are robust to different modeling approaches, including using a random effects model rather than clustering standard errors by firm, 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" and explained attributed 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.[54] 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 in terms of the Yale EPI index significantly alters the results.

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 on which we have 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. Unfortunately, we were only able to identify a reliable data source for such resolutions for a subset of the firms in our analysis. In this more limited set of cases (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).

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. As our theory suggests, we suspect 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 political regulation that moves in the same direction. 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, if not business, with the goals of their regulators, or that political commitments may not readily translate into business practices. This provides additional evidence for social movements and NGOs who accuse oil and gas companies of greenwashing their behavior.

Similarly, we find that the size of the refining sector is an important correlate of opposition to decarbonization in all our models, although it loses significance in the business model. As elaborated above, companies with a larger refinery footprint are the least flexible in a carbon-constrained world, so they should be more likely to resist the transition. Firms that have large refining sectors may therefore have large internal constituencies pressuring the firm to resist. Refineries are notoriously hard to reconfigure to handle different types of crude oil, e.g. ultra-light oil versus extra-heavy oil (the latter

[54] See, e.g. Levy and Kolk 2002; Skjærseth, Bang, and Schreurs 2013; Mildenberger 2020.

being more carbon intensive). So, 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. But still, this is one possible pathway that explains the negative correlation we find in our data.

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 the effect of these initiatives is more hortatory than action-based. 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, it is difficult to say for certain based on this analysis whether firms join coalitions and are influenced by their peers or whether they join coalitions in anticipation of their future behavior.

Several of the other variables did not appear to be statistically significant in our models but deserve further attention. We find that firms that are more diversified in the market for their products tend to be more likely to hedge, especially on the political dimension. This suggests that firms that work in multiple markets may prefer a political strategy that promotes harmonization across jurisdictions with different levels of regulation.[55] In contrast, and consistent with our theory above, we find that 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 the sales and poor-performing in terms of business outcomes. As expected, expenditures on research and development 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 hedging 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. In contrast, firms engage in more pro-climate political behavior when oil prices are low. This could reflect increased confidence on the part of firms regarding the viability of fossil fuels in a carbon-constrained world, 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 much

[55] Vogel and Kagan 2004.

more research is needed to explain the mechanisms underpinning such a relationship.[56] This is consistent with other work that conceptualizes decarbonization as a process of overcoming carbon lock-in.[57]

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 these 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. This limits the statistical power of the analyses we are able to present. 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. Taking into account these limitations, we plan a few case studies to the next version of the paper to help illustrate the mechanisms by which these variables may be related.

7. Looking Ahead: Prospects for Transition

This paper has outlined a two-part framework through which to understand the political economy of oil and gas firm decarbonization. Our main findings are three. Generally speaking, firms are talking the talk without walking the walk. Business behavior has moderated over time, but it has not been accompanied by efforts true decarbonization. Some firms have improved, but mostly through a transition to fossil gas, with the most minimal investments in renewables. On the political side, 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.

Our findings also demonstrate the importance of regulation. In line with expectations, initial empirical results suggest a critical role for climate policy in the jurisdictions in which firms operate in explaining the variation across firms, as well as the capacity of firms to adapt to new business models.

Importantly, our results on past behavior do not necessarily predict future behavior. Our theoretical approach does not necessarily imply that the empirical record to date is the best prediction of firm behavior to come. Critically, because the model emphasizes how firms' behavior shapes both policy and the behavior of other firms, it highlights the possibility of non-linear shifts. Going forward, the model draws our attention to several important dynamics that will shape prospects for further decarbonization.

First is the ongoing COVID-19 crisis. The direct 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, potentially non-competitive firms. A number of the oil majors have

[56] Henriques and Sadorsky (2011) find a similar non-linear relationship between oil price volatility and the general investment levels of non-financial firms. This conforms with the strategic growth options literature on how uncertainty similarly affects investment decisions at both extremes of the volatility spectrum.
[57] Unruh 2000.

taken massive write-downs in the wake of COVID-19. As a result of these losses, and the uncertain future for fossil fuels, Exxon has recently been dropped from the Dow Jones Industrial Average.

Second, the role of climate policy in the United States, as a major oil and gas producer and consumer, and the headquarters of several oil and gas majors, is critical. If political changes lead to aggressive policies, we should expect greater convergence across US and EU firms. Aggressive policies, in turn, could help further cement forward progress on renewables, and earmark funds for more R&D. More generally, the role of domestic politics and institutions cannot be understated. We find that HQ regulation affects the majors' political and business strategies. Leadership may come from forward-looking firms, but they will have to be pushed by government rules.

Third, a key dynamic we have not yet been able to test revolves around how firms are affected by the actions of others. If some firms move more aggressively toward transition, there are 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. As our model posits, which tendency prevails is conditional on two factors: the ability of firms to shape their political environment and firms ability to shift business models. For example, it is possible to imagine a scenario in which Europe benefits from the positive self-reinforcing dynamic, as greater regulatory pressure, less scope by firms to resist regulation, and more firm adaptability creates conditions that push toward transition. At the same time, the US may suffer a negative feedback, in which relatively weak regulations are insufficient to pressure incumbent firms with legacy investments and relatively cheap, long-lived fossil assets, notably natural gas.

Fourth, it is useful to consider what aspects of this model generalize to other firms and sectors. Two key variables—policy and firms' ability to change—are particularly relevant. On policy, our findings regarding the centrality of the home jurisdiction should be *more* true for national oil companies than the market-driven firms considered here. However, there is likely an even greater influence of endogeneity, since climate policy and oil and gas profitability are so closely linked. In general, we should expect laxer policy in nations with large NOCs. Anecdotal evidence supports this conjecture, as seen in countries like Russia and Saudi Arabia.

As with most technological transitions, past behavior is not an indication of future trends. As such, while it is clear that oil and gas firms are falling well short of the changes needed to decarbonize, it is possible that other forces could accelerate the process.

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Appendix

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

Table A2: 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
Anglo-American 2017	-	-	-	-17
BHP 2017 BHP 2019	- -	- -	- -	-25 -24
BP 2017 BP 2018 BP 2019	- E+ -	- 53 -	- 30 -	-31 - -47
Chevron 2017 Chevron 2018 Chevron 2019	- F -	- 29 -	- 4 -	-49 - -58
ConocoPhilips 2017 ConocoPhilips 2019	- -	- -	- -	-28 -29
ExxonMobil 2017 ExxonMobil 2018 ExxonMobil 2019	- E -	- 41 -	- 56 -	-52 - -48
Occidental 2017 Occidental 2019	- -	- -	- -	-16 -24
Shell 2017 Shell 2018 Shell 2019	- D -	- 49 -	- 55 -	-26 - -30
Total 2017 Total 2018 Total 2019	- D -	- 29 -	- 52 -	-31 -25
ENI	-	-	-	-
Repsol	-	-	-	-
Statoil	-	-	-	-

Table A3: Descriptive Statistics

Summary Statistics	N	mean	min	max	std. dev
Combined Business and Political DV	110	-0.99	-1.82	0.68	0.64
Political DV	110	-0.48	-1	1	0.62
Business DV	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 A4: 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 A5: 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 A6: 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 A7: 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 A8: Membership Lagged

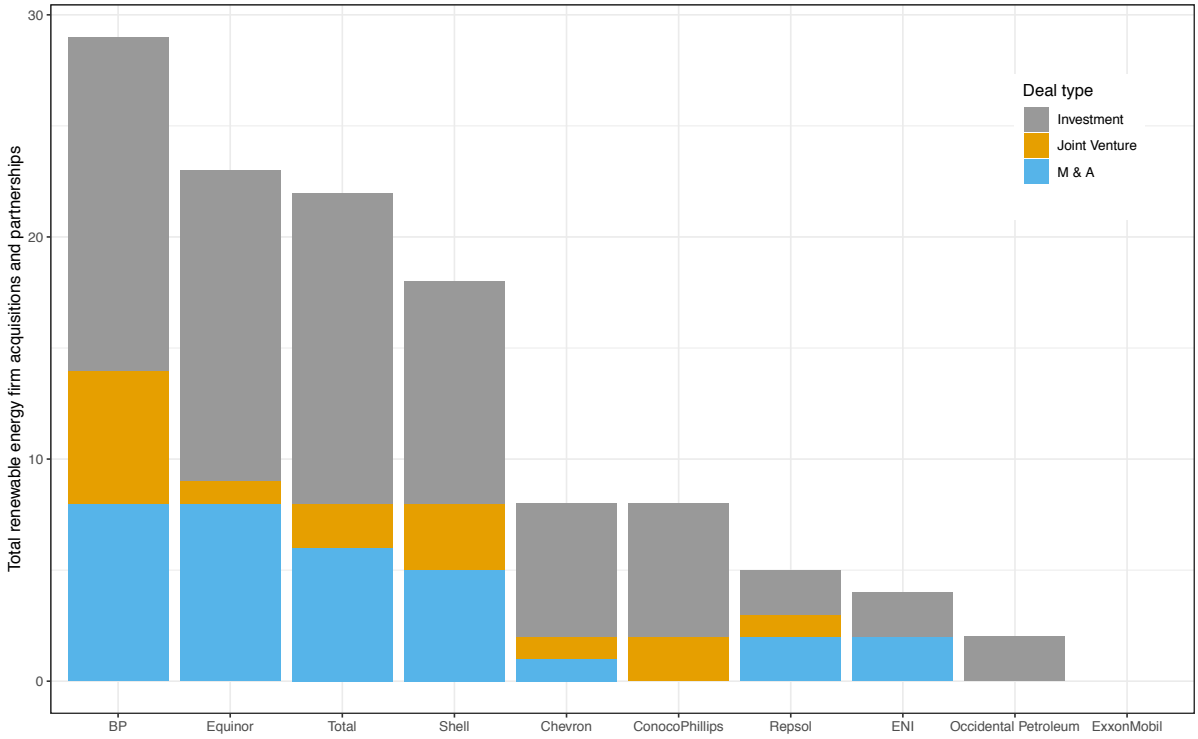
	Model 1	Model 11	Model 12	Model 13
Emissions Regulation HQ	0.103***	0.105***	0.099***	0.114***
	(0.027)	(0.025)	(0.028)	(0.026)
Diversification	0.004	0.005	0.003	0.003
	(0.003)	(0.004)	(0.004)	(0.004)
Refining (log)	-0.459**	-0.365*	-0.370*	-0.340
	(0.174)	(0.180)	(0.161)	(0.192)
R&D	0.028	0.009	0.037	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

Table A9: Codebook for Shareholder Calls

Key words	Indicators and values
"Climate change"/ "Climate science" "Global warming"/"Greenhouse gas/gasses"	**>Does company accept climate science?** 3 Accept 2 Partial acceptance (including downplaying or minimizing) 1 Reject 0 No mention
"Environmental protection/regulation" "Regulation"/"Regulatory"/"Government policy" "Treaty"/"Kyoto"/"Paris Agreement/goals"	**>Does company support international agreements (specifically Kyoto Protocol, Paris Agreement)?** 3 Support 2 Neutral 1 Reject 0 No mention **>Does company support key national laws and policies (e.g. Waxman – Markey, CAFÉ standards, EU policies, NDCs, etc)?** 3 Support 2 Neutral 1 Reject 0 No mention
"Emission"/ "Emission market/trading" "Fuel efficiency"/"carbon pricing"	**>Does company support carbon-pricing (as a concept)?** 3 Support 2 Neutral 1 Reject 0 No mention
"CCS"/"Carbon capture"	**>Does company support CCS?** 3 Company is pursuing it 2 "Someone" should pursue it 1 Reject 0 No mention
"Divestment"/"Future energy"/"decarbonize"	**>Does company accept that there will be an end to burning fossil fuels?** 3 This century 2 Some vague point in the future 1 No 0 No mention
Company or investor	**Company or Investor: Who is speaking?** 1 company 0 investor/shareholder/other
Company Response contains no keywords	**If investor speaking, register if Company Response contains no keywords** 1 no keywords 0 not aplicable
Parragraph unclear?	**Parragraph unclear?** 1 Unclear 0 Clear

Appendix Figure 1. Renewable energy deals by 10 major fossil fuel firms, 2001-2019



Appendix Figure 2: Earnings Calls by Firm and Period