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.*

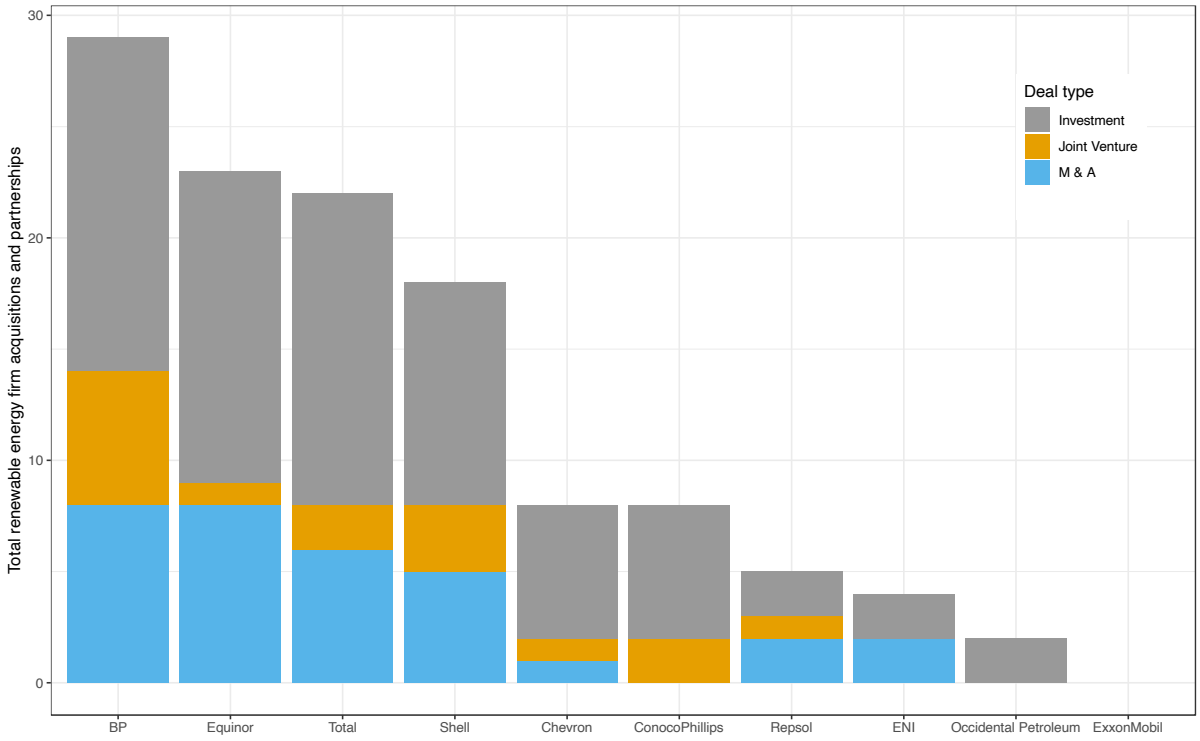

Figure A2: Emissions and energy efficiency trends, top 10 major oil and gas firms, 2005-2018. *Total greenhouse gas emissions in million metric tons (top left); greenhouse gas emissions efficiency in metric tons per thousand dollars revenue (top right); methane flaring in metric tons per million barrels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