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Consumers

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# Equity, Commodity, and Distillate Risk for Oil Upstream Producers and Downstream Consumers

## Abstract

The oil and gas industry's role in economic activity is hard to overstate. This study considers upstream, midstream, and downstream oil producer returns and risk compared to downstream oil consumers in airlines, ground-freight, railroads, and tire manufacturing. Between 2000 and 2020, the oil and gas industry had the lowest expected returns, greater risk, and only Integrated producer returns approached downstream oil and gas consumer risk-return profiles. Railroad companies were the least risky with the highest returns, followed by tire manufacturers, airlines, and freight companies. Equity, commodity, and distillate markets positively price risk into oil and gas producer returns, and upstream producers had greater project and equity market risk than downstream consumers. Most downstream oil consumer equity returns are positively related to equity and commodity market risk, while a few downstream commercial consumers have negative equity and commodity return variation, indicating that crude oil is an input to downstream consumers.

JEL-Codes: L620, L720, L930, L910, L920.

Keywords: oil and gas, air transportation, ground freight, railroads, tire manufacturing.

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## **I. Introduction**

The oil and gas industry's role in economic activity is hard to overstate, and the industry has long been associated with contemporary economic development. Oil and gas are the primary energy inputs for most domestic and international transportation, and oil is a primary input for various downstream consumers, such as airlines, ground-freight (trucking), rail transportation, and tire manufacturing. A primary reason that oil and hydrocarbons are prominent in modern economies is their flexibility and energy density that is currently not found in other energy sources. Energy density is the amount of energy in a system, and relative to alternative energy sources, crude and hydrocarbon energy density and efficiency remain high. In international energy markets, the US is a long-time oil and gas consumer, and after decades as a net importer, since 2018, the United States is a leading oil producer (EIA, 2023). Subsequently, the US oil and gas industry has a pervasive role across multiple US industries and international markets that are related to various stages of economic production.

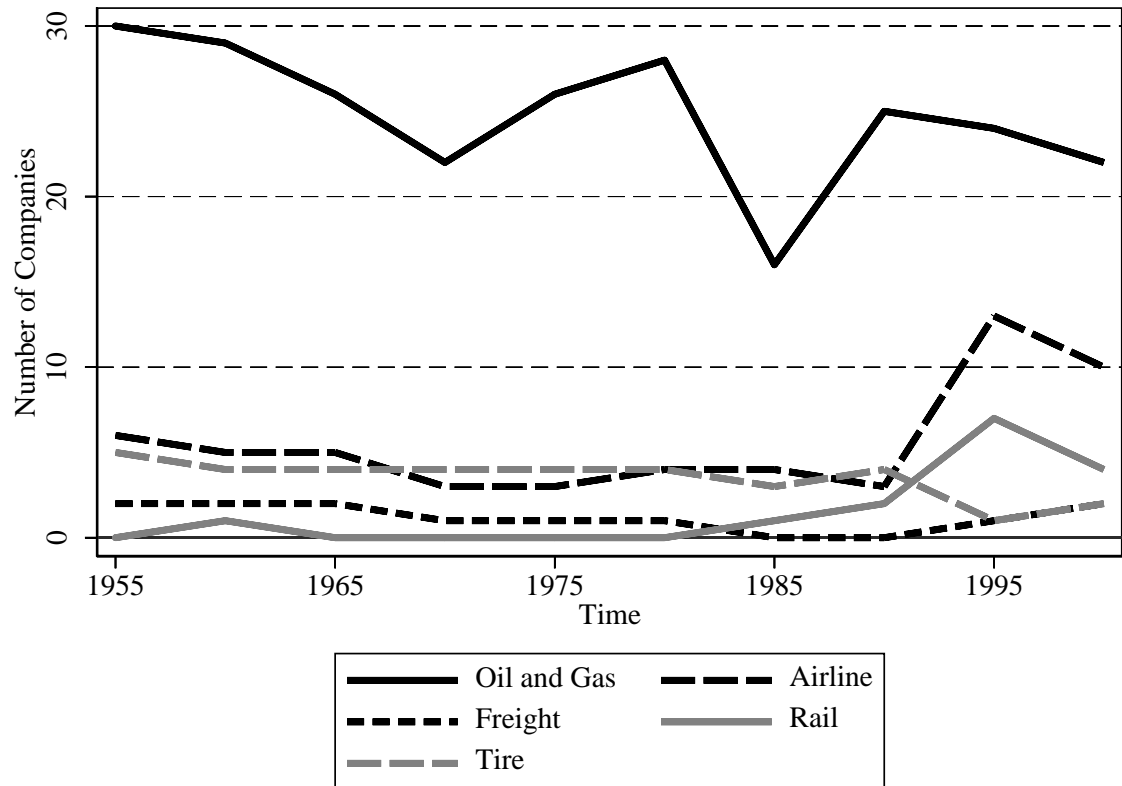
Commercial hydrocarbon production developed in the US, and oil and gas production began with a high degree of market concentration (Yergin, 1991). International crude prices are largely determined by state-owned oil producers, while private domestic exploration & production and equipment & services remain competitive. Saudi-Aramco, the National Iranian Oil Company, Petróleos Mexicanos (Pemex), and Petrobras de Venezuela (PDVSA) are primary state-owned crude producers. Private US and international producers take oil's price as determined in international crude markets, and private independent US oil producers are competitive across upstream, mid-stream, and downstream production (FTC, 1982, p. 8).

To better understand the oil and gas industry and its relative position with downstream commercial consumers, the oil and gas industry is partitioned here into four sectors (FTC, 1982, p. 8). Firms in upstream exploration & production discover and extract hydrocarbons and are closest to crude oil and natural gas production. Equipment & service firms are complementary to exploration & production firms that maintain, frack, and service wells once brought into production (Carson, 2022b). Transportation & pipeline firms are mid-stream producers that transport, measure, and store crude once in the production stream, and around 70 percent of US crude is transported through pipelines (FTC, 1982, p. 14). Refining & marketing are downstream producers that refine and distribute crude and natural gas to downstream consumers. Integrated firms are Super Majors that are integrated into each part of the upstream, midstream, and downstream oil and gas industry. Integrated and refining & marketing firms service retail markets that use petroleum-based products for domestic and international consumption. Given time in the industry, access to credit, and large cash reserves, Integrated firms face lower financial risk than smaller specialized producers in other parts of the industry.

Downstream industrial oil and gas consumers developed with the oil and gas industry, and a primary interest associated with crude-based products are the speed with which they transport passengers and cargo. Air transportation, freight, railroads, and tire manufacturing are four industries that rely on the oil and gas industry as an energy source, and the passenger and airline freight industries are possible because petroleum products have the energy density to power the commercial and cargo airline industries (Bryce, 2008, pp. 127-128; EPA 2012, 2013, Today in Energy). Travel and freight airlines transport individuals and freight between locations (Table 1). Firms in the ground-freight industry offer long-distance logistic alternatives to air freight between surface destinations and use considerable amounts of oil-based fuels. Railroads

rely on diesel fuel refined from crude oil, and railroad freight shipping rates are lower than other forms of transportation. Tire manufacturing is an industry that uses crude oil in manufacturing to create synthetic rubber derived from petroleum products (Tiremart, 2021; Dunn Tire, 2012). Subsequently, oil and its refined products are important components of air, ground-freight, rail, and tire manufacturing.

**Figure 1, Oil and Gas, Airline, Ground Freight, Railroad, and Tire Manufacturing  
Representation on the Fortune 500 Representation since 1955**



One means of evaluating the dynamics in the oil and natural gas industry is comparing firm duration over time with downstream consumers. The number of firms in each sector on the Fortune 500 illustrates the importance of oil and gas, ground-freight, rail, and tire manufacturing in US industry. Over time, the oil and gas industry has composed the greatest number of firms on the Fortune 500 (Figure 1). Since 1955, only 52 firms have continuous representation on the Fortune 500. Of these, four are oil and gas, airline, ground freight, railroad, or tire manufacturers. ExxonMobil, Chevron, and ConocoPhillips have been on the S&P 500 each year since 1955, while Goodyear Tire & Rubber is the only commercial oil consumer continuously on

the Fortune 500.<sup>1</sup> The number of downstream oil and gas consumers remained constant until around 1990, when the transformation of the US economy began to favor domestic travel and rail companies.

It is against this backdrop that this study uses augmented five-factor Fama-French equity, commodity, and distillate return models to evaluate upstream oil and gas industry producer returns and risk in relation to downstream air, ground freight, railroads, and tire manufacturer's returns and risk. Three questions are considered. First, how do different oil sector returns vary with equity, commodity, and distillate market risk and proximity to oil production? Equity and commodity markets positively price oil producer returns that vary with equity market and project risk, and upstream producers have higher equity, commodity, and distillate market risk closer they are to production. Second, how do different downstream consumer returns vary with the oil industry? Most oil consumer returns are positively related to equities, while some downstream consumers have negative commodity return variation when it is used and an energy input. Third, how do oil and gas producer and consumer returns in different downstream oil consumption industries vary with equities, commodity, and distillate return variation? There are systematic inverse risk-return relationships between upstream producers and various downstream consumers that use crude oil, indicating that crude oil is an important input into downstream production.

## **II. Oil, Gas, and Downstream Consumer Markets and Schumpeterian-Financiers**

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<sup>1</sup> Because the two aircraft and airline firms are Boeing and Lockheed Martin, which are aircraft manufacturers, and their commercial operations do not exclusively rely on petroleum as a primary input.



**Table 1, Oil & Gas, Airline, Ground Freight, Railroads, and Tire Manufacturers**

	<b>Oil &amp; Gas</b>		<b>Airlines</b>	<b>Ground Freight</b>	<b>Railroads</b>
<i>Exploration &amp; Production</i>	<i>Equipment &amp; Services</i>	<i>Integrated</i>	Alaska	Covenant	BRK b
Antero	Baker Hughes	BP	Allegiant	Daseke	Canadian National Railroad
Apache	Fluor	Chevron	American	Forward Air Freight	Canadian Pacific Railroad
Cabot	Halliburton	ConocoPhillips	Atlas	Heartland	Caterpillar
Chesapeake	Helmerich & Payne	ENI	Boeing	JBHunt	CSX
Cimarex	Nabors Drilling	Exxon	Cathay	Knight Swift	Kansas Southern
CNX	National Oilwell Varco	Hess	Chinese Southern	Landster	Norfolk Southern
Concho	Nextier Oilfield	Murphy Oil	Delta	Marten Express	Union Pacific
Continental	Patterson Drilling	Petrobras	Fed Ex	Old Dominion	Wabtec
Devon	Precision Drilling	Petro China	Jet Blue	PAM Transportation	
Diamondback	Savannah Drilling	Royal Dutch Shell	US Global	Penske	<b>Tire Manufacturers</b>
EOG	Schlumberger	Total	Ryan Air	Roadrunner	Bridgestone
EQT	TechniFMC		Singapore	Ryder	Cooper
Equinor	Tidewater		Skywest	Saia Transportation	Goodyear
Laredo Petroleum	Western Energy Services		Southwest	Schneider	Michelin
Marathon Oil			Spirit	Werner	
Noble	<i>Transportation &amp; Pipeline</i>		United	XPO Logistics	
Oasis Petroleum	Cheniere		UPS	YRC Holland	
Occidental	Kinder Morgan		Total		
Ovintiv	One OK				
Permian Basin Trust	Whiting				
Pioneer					

Range	<i>Refining &amp; Marketing</i>
SM Energy	Holly Frontier
Southwestern	Marathon Petroleum
Sun	PBF
Vaalco	Valero
WPX	

Notes: Corporations on major equity exchanges.

Table 1 lists companies in the upstream oil and gas production, and downstream consumer sectors used in this study. The oil and gas industry is segregated into upstream, midstream, and downstream production. Crude oil and its distillates in downstream oil and gas consumption are also included. Industries and innovators rely on well-informed Schumpeterian-financiers to extend credit to new projects and infrastructure, and financiers have incentives to be informed regarding project profitability and risk (Bodenhorn, 1998, p. 106; Bodenhorn, 1999, pp. 279-280, 283-284; Akchigit et al. 2019). Schumpeterian-financiers assimilate equity, commodity, and distillate market information into prices that determine firm value. In each sector, there are various publications to inform innovators, project managers, and financiers regarding profitability and risks associated with technology and industry conditions (Table 2). The oil, airline, ground freight, railroad, and tire manufacturing industries are capital intensive, and high capital expenses limit entry into each industry. Innovation is driven by skilled agents who create new technologies (Zuckerman, 2013, pp. 1-6), and downstream airline, freight, railroad, and tire manufacturing rely on oil and gas industry innovation to keep input prices at reasonable levels. There is a cottage publication industry for oil and gas, airline, ground freight, railroad, and tire manufacturers that inform innovators, industry executives, and market participants with information to evaluate project and market risk (Table 2). Well informed Schumpeterian-financiers also inform commodity market participants of relevant information and downstream oil and gas consumers.

**Table 2, Oil & Gas, Airline, Freight, Rail, and Tire Industry Publications**

<b>Oil &amp; Gas</b>	<b>Airlines</b>	<b>Railroads</b>	<b>Tire Manufacturers</b>
Oil & Gas Journal	Airlines International	Pacific Rail News	Tire Science & Technology
World Oil	Flight Global	Rail News	
Pipeline Oil & Gas Magazine	Aviation Week	Railroad Gazette	
American Oil & Gas Reporter	Flying  Air & Space Magazine	Railroads Illustrated Railroad Age	

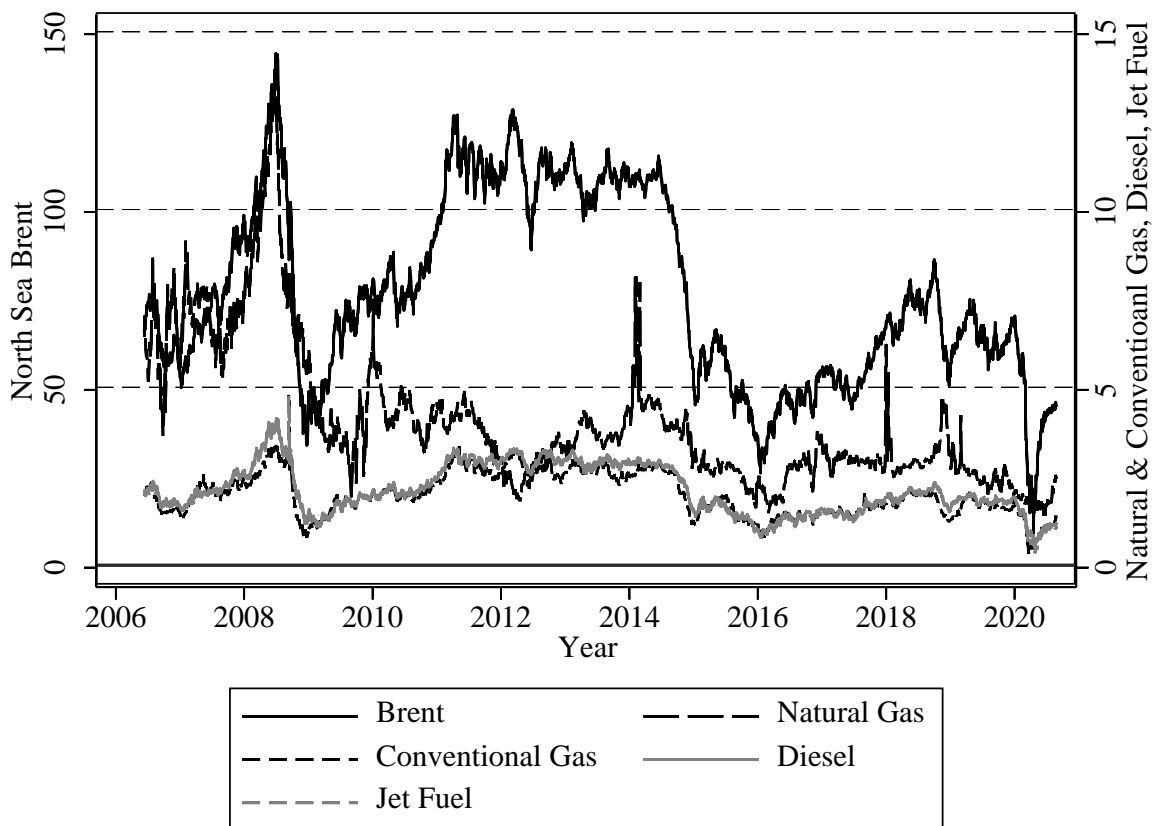
This study uses information available to Schumpeterian-financiers and informed project managers to extract relevant market information and assess risk across industries (Table 2). Subsequently, well-capitalized and informed financial intermediaries, financial market participants, and Schumpeterian-financiers assess risk and returns across various industries, and distillate market risk for firms related to the oil and gas industry and downstream oil and gas consumers (Bodenhorn, 1998, p. 106; Bodenhorn, 1999, pp. 279-280, 283-284; Akeigit et al, 2019).

### **III. Data**

Data used in this study are daily returns between January 2000 and August, 2020. There are 26 firms in exploration & production, 12 firms in equipment & services, four firms in transportation & pipeline, four firms in refining & marketing, and 10 Integrated oil and gas producers. Among downstream oil and gas consumers, 14 firms are in airline transportation, 17 are in ground-freight, nine are in railroads, and four are in tire manufacturing. North Sea Brent is the international crude oil benchmark, and natural gas is measured with Henry Hub prices at

Erath, Louisiana.<sup>2</sup> Conventional gas returns are the rate of return on Gulf Coast conventional gas. Diesel returns are from US Gulf Coast ultra-low sulfur No. 2 diesel fuel price. Aviation fuel is the kerosine-type jet fuel from the US Gulf Coast.

**Figure 2, Crude Oil, Natural Gas, Conventional Gas, Diesel, and Jet Fuel**



Source: Federal Reserve Economic Data. <https://fred.stlouisfed.org/searchresults/?st=gdp&isTst=1>

<sup>2</sup> Liquefied and condensed natural gas are similar but not equivalent. Liquefied natural gas is frozen to make it a liquid form, whereas condensed natural gas is pressurized to make it compact.

**Table 3, Crude, Natural and Conventional Gas, Diesel, Aviation Fuel, and S&P Correlation**

<i>Prices</i>	<i>Brent Crude</i>	<i>Natural Gas</i>	<i>Conventional Gas</i>	<i>Diesel</i>	<i>Jet Fuel</i>	<i>S &amp; P 500</i>
Brent Crude	1					
Natural Gas	.358	1				
Conventional Gas	.965	.370	1			
Diesel	.986	.438	.962	1		
Jet Fuel	.982	.447	.963	.996	1	
S & P 500	-.414	-.499	-.399	-.406	-.418	1
<b>Rate of Return</b>	Brent Crude	Natural Gas	Conventional Gas	Diesel	Jet Fuel	S & P 500
Brent Crude	1					
Natural Gas	.076	1				
Conventional Gas	.550	.033	1			
Diesel	.577	.047	.619	1		
Jet Fuel	.588	.046	.669	.847	1	
S & P 500	.246	.026	.331	.351	.341	1

Source: North Sea Brent crude retrieved from <https://fred.stlouisfed.org/series/DCOILBRENTU>. Henry Hub natural gas: <https://fred.stlouisfed.org/series/DHHNGSP>. Conventional gas: <https://fred.stlouisfed.org/series/DGASUSGULF>. Diesel: <https://fred.stlouisfed.org/series/DDFUELUSGULF>. Jet Fuel: <https://fred.stlouisfed.org/series/WJFUELUSGULF>.

Commodity prices and returns vary over time (Figure 2), and crude and distillate prices are highly correlated with diesel, jet fuel, and conventional gas prices (Table 3). However, crude oil prices and natural gas prices are not related to conventional gas prices (Carson, 2020), while North Sea Brent and distillate prices are inversely related to the S&P 500, whereas crude rate of returns are highly related to diesel, jet fuel, and conventional gas. Natural gas prices are not related, return correlation are considerably lower than prices. S&P 500 correlations with commodity and distillates are positive, and like prices, natural gas rates of return are not related

to commodities and distillates. Like prices, natural gas returns are not related to commodities and distillates, while S&P 500 correlations with commodity and distillates are positive.

**Table 4, Oil & Gas Sector Industry Returns, Standard Deviations, and Sharpe Ratios**



	<i>N</i>	<i>Mean</i>	<i>Median</i>	<i>SD</i>	<i>Skewness</i>	<i>Kurtosis</i>	<i>Sharpe Ratio</i>
<b>Exploration &amp; Production</b>							
Apache	3,627	.000203	.000517	.032333	-1.3935	41.529	.00628
Cabot	3,604	.000750	0	.027771	.312750	9.3008	.02701
Chesapeake	3,543	-.000379	0	.060357	9.0073	274.586	-.00628
Cimirex	3,604	.000465	.000369	.029382	-.114340	16.984	.01583
CNX	3,543	.000433	0	.037455	.236386	9.1688	.01156
Concho	3,261	.000919	.000703	.030985	.165192	12.246	.02966
Continental	3,378	.001084	.000399	.040028	-.107800	18.679	.02708
Devon	3,543	.000024	0	.028719	-.237746	17.605	.00084
DiamondBack	1,962	.000937	.001237	.030992	-1.4328	30.490	.03023
EOG	3,604	.000522	.000279	.026078	-.190138	14.980	.02002
EQT	3,543	.000370	.000251	.027019	1.1055	20.276	.01369
Equinor	3,604	.000336	.000444	.023565	-.300197	9.7619	.01426
Laredo	2,164	-.000156	0	.052855	5.09754	112.653	-.00295
Petroleum							
Marathon Oil	3,543	.000145	.000488	.026683	-.720377	25.5546	.00543
Noble	3,542	-.000687	-.000563	.052172	8.4979	288.705	-.01317
Oasis	2,540	.000607	.000350	.069020	10.691	247.869	.00880
Petroleum							
Occidental	3,543	.000148	.000331	.026753	-1.3376	57.9213	.00553
Ovintiv	3,543	.000065	0	.034082	-2.0268	65.3351	.00191
Permian Basin Trust	3,543	.000084	0	.022123	-.106840	10.8200	.00380
Pioneer	3,543	.000722	.000525	.029149	-.499342	16.1039	.02477
Range	3,543	.000259	-.000527	.033414	.621245	10.8359	.00775
SM Energy	3,543	.000271	0	.044841	1.1336	41.5192	.00604
Southwestern	3,543	.000166	-.000501	.035629	.529988	11.2379	.00466
Sun	1,978	.000714	.000298	.024101	.344800	30.4479	.02963
Vaalco	3,543	.000334	0	.042296	.594272	9.2799	.00790
WPX	2,172	.000413	0	.03857	.206690	13.926	.01071
Total	3,217.59	.000300	.000128	.03575	1.1552	52.9676	.01016
<b>Equipment &amp; Services</b>							
Baker Hughes	3,543	.000035	0	.026729	.015971	13.256	.00131
Fluor	3,543	.000126	.000496	.032221	2.9991	100.019	.00391
Halliburton	3,543	.000232	.000193	.028116	-.681526	21.751	.00825
Helmerich & Payne	3,543	.000441	.000835	.030700	-.232772	14.321	.01437
Nabors Drilling	3,543	-.000056	-.000386	.043161	.645913	20.1985	-.00130
National	3,543	.000292	.000513	.030690	-.226982	13.5445	.00952
Oilwell Varco							

Nextier Oilfield	892	-.00102	-.001367	.049814	.793208	18.5855	-.02047
Patterson Drilling	3,543	.000144	0	.035394	-.318833	16.0630	.00407
Precision Drilling	3,543	-.000243	0	.037535	-.306758	12.0730	-.00647
Schlumberger	3,543	.000075	-.000126	.024358	-.508687	14.1638	.00308
TechniFMC	3,543	.000319	.000372	.028341	-.230206	11.6028	.01126
Tidewater	3,543	-.000728	.000318	.037475	-.402360	17.0548	-.01943
Total	3,322.08	.000003	.000007	.033711	.128839	22.7194	.00067
<b>Integrated</b>							
BP	3,543	.000882	.000292	.019869	-.184316	19.0850	.04439
Chevron	3,543	.000424	.000852	.018547	.087591	27.7742	.02286
ConocoPhillips	3,533	.000255	.000355	.022039	-.066675	18.9775	.01157
ENI	3,543	.000142	.000711	.020375	-.462954	13.4512	.00697
Exxon	3,545	.000159	.000151	.016452	.179705	17.0156	.00967
Hess	3,543	.000685	.000644	.028596	-.419256	14.3181	.02395
Murphy Oil	3,543	.000265	.000406	.029706	-.470867	22.2233	.00892
Petrobras	3,543	.000514	.000837	.034975	.051882	11.5049	.01470
Petro China	3,543	.000114	-.000293	.023300	.307390	9.18932	.00489
Royal Dutch	3,568	.000176	.000754	.019704	-.086507	20.3877	.00893
Shell							
Total	3,543	.000281	.000779	.019394	-.254471	13.7411	.01449
<b>Refining &amp; Marketing</b>							
Holly Frontier	3,543	.000668	.001063	.029857	.105311	8.9380	.02237
Marathon Petroleum	771	.000210	.000249	.034218	-.235689	14.3441	.00614
PBF	401	-.001642	-.00338	.059660	.538368	7.8889	-.02752
Valero	3,543	.000464	.000906	.056699	-.303394	10.6346	.00818
Total	2,823.50	.000643	.003603	.037246	.060269	16.1075	.01684
<b>Transportation &amp; Pipeline</b>							
Cheniere	3,543	.001100	0	.045356	2.2391	37.6613	.02425
Kinder Morgan	2,435	.000075	0	.019740	-.032127	18.6932	.00380
One OK	3,543	.000683	.00104	.024814	-.377376	47.2699	.02753
Whiting	3,543	.000343	.000217	.061787	8.1215	179.505	.00555
Total	3,266	.000550	.000314	.037924	2.4878	70.7824	.01528

Notes: Corporations on major equity exchanges.

Source: Returns calculated from adjusted daily price close.

**Table 5, Airline Industry Returns, Standard Deviations, and Sharpe Ratios**

	<i>N</i>	<i>Mean</i>	<i>Median</i>	<i>SD</i>	<i>Skewness</i>	<i>Kurtosis</i>	<i>Sharpe Ratio</i>
Alaska	3,543	.000879	.000900	.029561	.425522	15.710	.02974
Allegiant	3,421	.000953	.000372	.029356	.786130	19.413	.03246
American	3,543	.000646	0	.044531	1.2166	19.582	.01451
Atlas	3,543	.000590	.000264	.033159	.116403	15.623	.01779
Boeing	3,543	.000549	.000802	.022214	.244475	23.424	.02471
Cathay	3,543	.000156	0	.023116	.321841	10.714	.00675
Chinese Southern	3,543	.001005	-.000611	.034577	.475695	7.6517	.02907
Delta	1,806	.000662	.000774	.025753	-.685517	26.671	.02571
Fed Ex	3,543	.000427	.000378	.019982	-.187818	9.7089	.02137
Jet Blue	3,543	.000502	0	.031520	.881946	14.313	.01593
US Global	1,325	.000026	.000875	.021184	-.403406	22.320	.00123
Ryan Air	3,543	.000679	.000373	.024081	-.026759	14.552	.02812
Singapore	2,642	-.000162	0	.019867	3.2292	139.583	-.00815
Skywest	3,543	.000667	.000744	.032048	.147106	29.365	.02081
Southwest	3,543	.000522	.000504	.022375	-.163534	9.7269	.02333
Spirit	2,304	.000763	.000341	.033202	.131805	23.534	.02298
United	3,546	.000984	.000155	.043499	1.3374	31.6139	
UPS	3,543	.000435	.000273	.015156	.270682	12.217	.02870
Total	3,177.29	.000581	.000346	.028825	.461611	25.502	.01939

Notes: Corporations on major equity exchanges.

Source: Returns calculated from adjusted daily price close.

**Table 6, Freight Industry Returns, Standard Deviations, and Sharpe Ratios**

	<i>N</i>	<i>Mean</i>	<i>Median</i>	<i>SD</i>	<i>Skewness</i>	<i>Kurtosis</i>	<i>Sharpe Ratio</i>
Covenant	3,543	.000851	0	.039894	.949638	16.177	.02133
Forward Air	3,543	.000417	.000374	.022403	-.134772	8.3358	.01861
Freight							
Heartland	3,543	.000334	0	.019359	.622239	10.522	.01725
JBHunt	3,543	.000740	.000261	.019643	.019062	8.1981	.03767
Knight Swift	3,543	.000534	0	.021987	.130454	6.5943	.02429
Landster	3,543	.000528	.000515	.019051	.178670	8.5233	.02772
Marten	3,543	.000682	0	.024694	.412041	11.371	.02762
Express							
Old Dominion	3,543	.000116	.00087	.023947	.530541	10.007	.00484
PAM	3,543	.000796	-.000345	.036078	1.2569	19.817	.02206
Transportation							
Penske	3,543	.000711	.000409	.028145	.594965	12.259	.02526
Roadrunner	2,564	-.000981	-.000415	.041450	-.240123	28.242	-.02367
Ryder	3,543	.000329	.000688	.024549	-.321191	8.4977	.01340
Saia	3,543	.001038	.000606	.030188	.260558	7.8626	.03439
Transportation							
Schneider	839	.000674	.000752	.020323	-.015982	4.5669	.03316
Werner	3,543	.000621	.000542	.020384	.074674	7.5800	.03047
XPO	3,543	.001374	0	.031423	.153935	9.9058	.04373
Logistics							
YRC Holland	3,543	-.000713	-.002367	.068837	1.1747	26.227	-.01036
Total	3,206.22	.000478	.000105	.029787	.48576	14.704	.02003

Notes: Corporations on major equity exchanges.

Source: Returns calculated from adjusted daily price close.

**Table 7, Railroad Industry Returns, Standard Deviations, and Sharpe Ratios**

	<i>N</i>	<i>Mean</i>	<i>Median</i>	<i>SD</i>	<i>Skewness</i>	<i>Kurtosis</i>	<i>Sharpe Ratio</i>
BRK b	3,543	.000464	.000210	.014515	.810905	20.0073	.03197
Canadian National Railroad	3,543	.000661	.001816	.016836	-.332641	8.55312	.03926
Canadian Pacific Railroad	3,543	.000772	.000539	.020312	-.039644	10.806	.03801
Caterpillar	3,543	.000533	.000431	.020783	-.037290	8.5722	.02565
CSX	3,543	.000862	.001085	.021553	.366319	11.865	.04000
Kansas Southern	3,543	.000870	.000715	.023939	-.019032	11.3124	.03634
Norfolk Southern	3,543	.000705	.000829	.020089	.018211	9.6618	.03509
Union Pacific	3,543	.000869	.000702	.018904	-.198985	8.6724	.04600
Wabtec	3,543	.000670	.000944	.023264	-.257963	11.9157	.02880
Total	3,543	.000712	.000808	.020022	.034431	11.263	.03568

Notes: Corporations on major equity exchanges.

Source: Returns calculated from adjusted daily price close.

**Table 8, Tiremaker Industry Returns, Standard Deviations, and Sharpe Ratios**

	<i>N</i>	<i>Mean</i>	<i>Median</i>	<i>SD</i>	<i>Skewness</i>	<i>Kurtosis</i>	<i>Sharpe Ratio</i>
Bridgestone	2,656	.000493	.000272	.015853	-.078831	8.5547	.03110
Cooper	3,543	.000940	.000596	.032598	.684755	19.4681	.02883
Goodyear	3,543	.000468	0	.031052	-.116383	8.62007	.01507
Michelin	2,642	.000475	.000174	.020554	-.222760	7.42011	.02311
Total	3,096	.000594	.000261	.025014	.066670	11.0158	.02453

Notes: Corporations on major equity exchanges.

Source: Returns calculated from adjusted daily price close.

**Table 9, Oil & Gas, Airline, Ground Freight, Railroad, and Tire Maker Industry Returns,  
Standard Deviations, and Sharpe Ratios**

	<i>N</i>	<i>Mean</i>	<i>Median</i>	<i>SD</i>	<i>Skewness</i>	<i>Kurtosis</i>	<i>Sharpe Ratio</i>
Oil and Gas							
Exploration & Production	3,217.59	.000300	.000128	.03575	1.1552	52.9676	.01016
Equipment & Services	3,322.08	.000003	.000007	.033711	.128839	22.7194	.00067
Transportation & Pipeline	3,266	.000550	.000314	.037924	2.4878	70.7824	.01528
Refining & Marketing	2,823.50	.000643	.003603	.037246	.060269	16.1075	.01684
Integrated	3,543	.000281	.000779	.019394	-.254471	13.7411	.01449
Average							
Airline	3,177.29	.000581	.000346	.028825	.461611	25.502	.01939
Ground	3,206.22	.000478	.000105	.029787	.48576	14.704	.02003
Freight							
Railroads	3,543	.000712	.000808	.020022	.034431	11.263	.03568
Tire	3,096	.000594	.000261	.025014	.066670	11.0158	.02453
Manufacturer							
Total	3243.85	.000460	.000706	.029741	.514012	26.5336	.017452

Notes: Corporations on major equity exchanges. Returns calculated from adjusted daily price close.

Source: See Tables 4 through 8.

Mandelbront (1963) and Fama (1965) demonstrate that equity returns are not normally distributed, are peaked, and have thicker tails than the normal distribution. Oil and gas returns are also not normally distributed, and oil producers in refining & marketing have the highest daily expected returns, followed by transportation & pipeline, exploration & production, Integrated, and equipment & services (Tables 4 through 9; Carson, 2020; Carson, 2022a). The oil industry is a high-risk industry, and firms in downstream transportation & pipeline have the highest standard deviations and risk, followed by refining & marketing, exploration & production, equipment & services, and Integrated firms. For midstream and downstream oil producers, there is a mis-match between when crude oil is purchased and when distillates are refined and delivered to market. During this period, the price of crude and distillates vary asymmetrically, exposing midstream and downstream oil producers to greater risk (Reuters, 2008; Edelhart, 2010, Morenne, 2022). In the equipment & services sector, equipment and technology require firms to remain up to date with oil and gas innovations, while competing with other oil and gas equipment & service firms. Sharpe Ratios are the ratio of expected returns to risk, and portfolio returns increase by adding equities with the highest Sharpe Ratios. Among oil producers, refining & marketing have the highest Sharpe Ratios, followed by transportation & pipeline. Integrated, and exploration & production. Return peakedness and tail thickness are pervasive across the oil and gas industry and among downstream consumers (Tables 4 through 9).

Within equity markets, capital flows to alternative projects, and oil and gas are only a fraction of potentially profitable projects related to energy (Singh, 2022), and railroad companies have the highest daily expected returns, followed by tire manufacturers, airline, and freight carriers. Railroad companies also have the lowest risk, followed by tire manufacturers, airlines,



and freight companies (Tables 6). Among upstream oil and gas producers, no section of the upstream industry has as high of Sharpe Ratios as average downstream industrial consumers. Across industries, railroads have the greatest returns to risk, followed by tire manufacturers, ground freight, and airlines. Upstream oil and gas producers consistently have lower Sharpe Ratios than downstream oil and gas consumers. As an industry, the oil and gas industry has the lowest expected returns; however, refining & marketing and transportation & pipeline have expected returns comparable to downstream oil and gas consumers, and only Integrated firms approach the lowest risk of downstream oil and gas consumers. Subsequently, downstream oil and gas consumers have greater expected returns, lower standard deviations, and higher Sharpe Ratios than upstream oil and gas producers.

#### IV. Results

Sector risk and returns vary across equity, commodity, and distillate markets; they also vary across downstream consumer markets. To assess risk across industries, pricing models are estimated for upstream oil and gas producers and downstream consumers in airlines, ground-freight, railroad, and tire manufacturing. Firm returns are regressed on S&P 500, North Sea Brent, natural and conventional gas, diesel, and aviation fuel. Models are estimated as GARCH (1, 1) models, which is standard in the equity returns literature.

$$R_{it} - R_{ft} = \theta_0 + \theta_1(R_{mt} - R_{ft}) + \theta_2(R_{ot} - R_{ft}) + \theta_3(R_{gt} - R_{ft}) + \theta_4(R_{cg} - R_{ft}) + \theta_5(R_d - R_{ft}) \\ + \theta_6(R_j - R_{ft}) + \theta_7SMB_t + \theta_8HML_t + \theta_9RMW_t + \theta_{10}CMA_t + \theta_{11}MOM_t + \varepsilon_t$$

$R_{it}$  is each firm's daily adjusted return.  $R_{ft}$  is the daily US three-month Treasury Bill rate.  $R_{mt}$  is Standard & Poor's daily rate of return for firms on the New York Exchange;  $R_{mt}$  is the

NYSE—American index for firms on the American Exchange;  $R_{mt}$  is the National Association Securities Automated Quotations index for firms on the NASDAQ.  $\theta_1$  is the sensitivity parameter for equity market systematic risk.  $R_{ot}$  is the daily return on North Sea Brent.  $\theta_2$  is the North Sea returns sensitivity parameter for oil's systematic risk.  $R_{gt}$  is the Henry-Hub daily rate of return on natural gas, and  $\theta_3$  is firm excess return variation with natural gas return variation.  $R_{cg}$  is conventional gas daily returns;  $\theta_4$  is firm excess return variation with conventional gas excess returns.  $R_d$  is diesel daily return variation;  $\theta_5$  is firm excess return variation with diesel excess return variation.  $R_j$  is aviation fuel daily returns;  $\theta_6$  is firm excess return variation with aviation excess return variation.  $SMB_t$ ,  $HML_t$ ,  $RMW_t$ , and  $CMA_t$  are small-minus-big, high-minus-low, robust-minus-weak, and conservative-minus-aggressive and completes equity market risk.  $\theta_7$ ,  $\theta_8$ ,  $\theta_9$ , and  $\theta_{10}$  are how firms' excess returns vary with respect to  $SMB_t$ ,  $HML_t$ ,  $RMW_t$ , and  $CMA_t$ .  $MOM_t$  is a daily momentum factor;  $\theta_{11}$  is how firm returns vary with momentum.

Firm returns in domestic air passenger returns are modeled dependent on equity, commodity, and jet fuel (Table 15). Because diesel is the primary distillate input in the freight and rail industries, freight and rail return models are dependent on equity, crude, and diesel (Tables 15 and 16). Tire manufacturer return variation with equity and commodity markets is less clear and because crude is used in synthetic rubber production, tire manufacturing returns are only regressed on equity, crude oil, and Fama-French equity factors (Table 19).

Table 10, Exploration &amp; Production Generalized Autoregressive Conditions Heteroskedasticity Models

	<i>Apache</i>	<i>Cabot</i>	<i>Chesapeake</i>	<i>Cimarex</i>	<i>CNX</i>	<i>Concho</i>	<i>Continental</i>	<i>Devon</i>	<i>Diamond Back</i>
Intercept	-4.17 <sup>-4</sup> (2.59 <sup>-4</sup> )	2.79 <sup>-4</sup> (3.42 <sup>-4</sup> )	-1.51 <sup>-4</sup> (3.34 <sup>-4</sup> )	1.17 <sup>-4</sup> (2.77 <sup>-4</sup> )	-1.80 <sup>-4</sup> (3.81 <sup>-4</sup> )	.001 (3.26 <sup>-4</sup> )	.001** (3.50 <sup>-4</sup> )	-.2.04 <sup>-4</sup> (2.52 <sup>-4</sup> )	.001* (4.36 <sup>-4</sup> )
S & P 500	1.02*** (.022)	.959*** (.029)	.953*** (.030)	.937*** (.028)	1.22*** (.043)	.967*** (.027)	1.05*** (.032)	.962*** (.025)	1.10*** (.053)
Brent	.124*** (.016)	-.024 (.019)	.108*** (.022)	.085*** (.016)	.003 (.023)	.120*** (.016)	.169*** (.022)	.061*** (.013)	.036* (.021)
Natural Gas	.008 (.005)	.034*** (.007)	.048*** (.007)	.014** (.007)	.032*** (.008)	.008 (.009)	.007 (.009)	.015*** (.005)	.006 (.010)
Conventional Gas	.059*** (.139)	.070*** (.002)	.081*** (.018)	.054*** (.016)	.058*** (.021)	.008*** (.016)	.046** (.022)	.043*** (.013)	.046** (.022)
Diesel	.148*** (.027)	.213*** (.031)	.122*** (.030)	.187*** (.028)	.160*** (.033)	.278*** (.041)	.375*** (.040)	.200*** (.024)	.129*** (.048)
Jet Fuel	.095*** (.028)	.013 (.033)	.140*** (.028)	.071** (.025)	.078** (.039)	-.021 (.040)	.095*** (.031)	.084*** (.024)	.112*** (.040)
SMB	.001** (.005)	.003*** (.001)	.003*** (.001)	.004*** (.001)	.005*** (.001)	.003*** (.001)	.005*** (.001)	.002*** (.001)	.005*** (.001)
HML	1.34 <sup>-4</sup> (.001)	.002*** (.001)	.003*** (.001)	.003*** (.001)	.003*** (.001)	.001 (.001)	.003*** (.001)	.003*** (.001)	.004*** (.001)
RMW	.001 (.001)	.003*** (.001)	4.27 <sup>-4</sup> (.001)	-.001*** (.001)	-.001 (.001)	-.002** (.001)	-.002** (.001)	.001* (.001)	-.010*** (.001)
CMA	.001 (.001)	-.003*** (.001)	-.005*** (.001)	1.97 <sup>-4</sup> (.001)	-.003** (.001)	.001 (.001)	-.001 (.001)	-.002** (.001)	.003 (.002)
MOM	-.003*** (3.08 <sup>-4</sup> )	-3.03 <sup>-4</sup> (4.04 <sup>-4</sup> )	-.001*** (.001)	-.002*** (3.51 <sup>-4</sup> )	-.004*** (.001)	-.003*** (4.44 <sup>-4</sup> )	-.004*** (.001)	-.003*** (3.49 <sup>-4</sup> )	-.004*** (.001)
N	3,267	3,604	3,543	3,604	3,543	3,261	3,378	3,543	1,962
Log Likelihood	9,483.55	8,858.62	7,705.01	9,285.91	7,946.99	8,081.71	7,852.45	9,475.37	4,819.70
Wald	9,684.26	2,202.45	3,152.65	3,920.58	2,529.57	3,749.08	4,681.47	4,798.77	1,843.74

Note: Appropriate market excess rate of return calculated from the daily adjusted close, less the daily 3-Month daily US Treasury rate.

Commodity excess return is Brent Crude return, less the daily 3-Month daily US Treasury rate. Natural Gas excess return is Henry Hub daily return, less the daily 3-Month daily US Treasury rate. \*\*\* statistically significant at .01. \*\* statistically significant at .05. \* statistically significant at .10.

Source: See Table 4.

Table 10, continued. Exploration &amp; Production Generalized Autoregressive Conditions Heteroskedasticity Models

	<i>EOG</i>	<i>EQT</i>	<i>Equinor</i>	<i>Laredo</i>	<i>Marathon Oil</i>	<i>Nobel</i>	<i>Oasis</i>	<i>Occidental</i>	<i>Ovintiv</i>
Intercept	1.54 <sup>-4</sup> (2.53 <sup>-4</sup> )	-3.44 <sup>-4</sup> (2.57 <sup>-4</sup> )	-1.73 <sup>-4</sup> (2.12 <sup>-4</sup> )	-3.14 <sup>-4</sup> (.001)	-4.07 <sup>-5</sup> (2.36 <sup>-4</sup> )	-.001* (3.26 <sup>-4</sup> )	3.15 <sup>-4</sup> (.001)	-2.39 <sup>-5</sup> (1.98 <sup>-4</sup> )	-2.73 <sup>-4</sup> (2.99 <sup>-4</sup> )
S & P 500	.951*** (.024)	.983*** (.027)	.752*** (.022)	1.07*** (.066)	1.08*** (.024)	1.07*** (.034)	1.12*** (.058)	.978*** (.021)	.778*** (.030)
Brent	.077*** (.014)	.035** (.017)	.129*** (.011)	.135*** (.029)	.097*** (.016)	.114*** (.019)	.246*** (.028)	.046*** (.012)	.104*** (.013)
Natural Gas	.006 (.006)	.038*** (.006)	.003 (.004)	.029** (.015)	-.004 (.006)	-.012* (.007)	.010 (.015)	.004 (.004)	.033*** (.006)
Conventional Gas	.048*** (.013)	.033** (.016)	.038*** (.010)	.075** (.032)	.082*** (.014)	.087*** (.018)	.104*** (.027)	.046*** (.011)	.083*** (.016)
Diesel	.216*** (.024)	.126*** (.025)	.135*** (.023)	.262*** (.072)	.189*** (.029)	.213*** (.035)	.414*** (.068)	.175*** (.019)	.194*** (.025)
Jet Fuel	.056*** (.020)	.014 (.024)	.080*** (.021)	.112* (.058)	.056* (.029*)	.054 (.036)	.116*** (.058)	.036** (.018)	.120*** (.023)
SMB	.002*** (4.32 <sup>-4</sup> )	.002*** (.001)	2.36 <sup>-4</sup> (3.97 <sup>-4</sup> )	.008*** (.001)	8.51 <sup>-5</sup> (.001)	.001 (.001)	.007*** (.001)	2.95 <sup>-4</sup> (3.68 <sup>-4</sup> )	.003*** (.001)
HML	.002*** (.001)	.001* (.001)	.001** (4.43 <sup>-4</sup> )	2.68 <sup>-4</sup> (.001)	.001* (.001)	-2.24 <sup>-4</sup> (.001)	-.001 (.001)	.001* (4.03 <sup>-4</sup> )	.001 (.001)
RMW	-3.84 <sup>-4</sup> (.001)	.003*** (.001)	1.69 <sup>-4</sup> (6.11 <sup>-4</sup> )	-.011*** (.002)	3.48 <sup>-4</sup> (.001)	.001 (.001)	-.007*** (.002)	.001 (.001)	.001 (.001)
CMA	-.002* (.001)	-.001 (.001)	.004*** (.001)	.014*** (.002)	.001 (.001)	-.003** (.001)	.005** (.002)	.001* (.001)	.002* (.001)
MOM	-.002*** (3.16 <sup>-4</sup> )	-1.61 <sup>-4</sup> (3.26 <sup>-4</sup> )	-.002*** (2.88 <sup>-4</sup> )	-.009*** (.001)	-.003*** (3.47 <sup>-4</sup> )	-.002 (3.94 <sup>-4</sup> )	-.006** (.001)	-.002*** (2.63 <sup>-4</sup> )	- (3.68 <sup>-4</sup> )
N	3,604	3,543	3,604	2,164	3,543	3,542	2,540	3,543	3,543

Log Likelihood	9,724.08	9,247.61	10,397.87	4,406.95	9,232.79	7,883.39	5,203.77	10,265.29	8,748.21
Wald	5,988.97	2,732.97	75.1963	3,027.63	4,286.21	3,663.14	3,161.34	5,135.31	5,290.50

Note: Appropriate market excess rate of return calculated from the daily adjusted close, less the daily 3-Month daily US Treasury rate. Commodity excess return is Brent Crude return, less the daily 3-Month daily US Treasury rate. Natural Gas excess return is Henry Hub daily return, less the daily 3-Month daily US Treasury rate. \*\*\* statistically significant at .01. \*\* statistically significant at .05. \* statistically significant at .10.

Source: See Table 4.

**Table 10, continued. Exploration & Production Generalized Autoregressive Conditions Heteroskedasticity Models**

	<i>PBT</i>	<i>Pioneer</i>	<i>Range</i>	<i>SM Energy</i>	<i>Southwestern</i>	<i>Sun</i>	<i>Vaalco</i>	<i>WPX</i>	<i>Total</i>
Intercept	-2.36 <sup>-5</sup> (2.44 <sup>-4</sup> )	-2.36 <sup>-5</sup> (2.44 <sup>-4</sup> )	-1.87 <sup>-4</sup> (3.57 <sup>-4</sup> )	1.84 <sup>-4</sup> (3.71 <sup>-4</sup> )	-4.23 <sup>-4</sup> (3.62 <sup>-4</sup> )	.001*** (4.12 <sup>-4</sup> )	-2.13 <sup>-4</sup> (.001)	.001 (.001)	7.92 <sup>-5</sup> (4.13 <sup>-4</sup> )
S & P 500	.401*** (.024)	1.09*** (.026)	.924*** (.037)	.954*** (.039)	.946*** (.037)	.571*** (.051)	1.06*** (.042)	.565*** (.062)	.941*** (.035)
Brent	.100*** (.014)	.067*** (.010)	.040* (.022)	.187*** (.021)	.006 (.022)	.009 (.019)	.018 (.027)	.279*** (.036)	.091*** (.019)
Natural Gas	.009 (.006)	.010 (.007)	.047*** (.007)	.040*** (.006)	.072*** (.007)	.015 (.010)	.011 (.012)	.020* (.010)	.019*** (.008)
Conventional Gas	.049*** (.013)	.060*** (.014)	.066*** (.020)	.082*** (.023)	.072*** (.020)	.036 (.022)	.090*** (.026)	.026 (.030)	.059*** (.023)
Diesel	.157*** (.024)	.247*** (.026)	.216*** (.038)	.254*** (.035)	.170*** (.034)	-.013 (.048)	.234*** (.043)	.201*** (.071)	.200*** (.036)
Jet Fuel	.012 (.024)	.043* (.025)	.065* (.035)	.107*** (.035)	.087** (.037)	.022 (.046)	.079* (.042)	.096 (.070)	.04** (.034)
SMB	.003*** (4.12 <sup>-4</sup> )	.003** (.005)	.006*** (6.64 <sup>-4</sup> )	.006*** (.001)	.005*** (.001)	-.001 (.001)	.011*** (.001)	.003** (.001)	.004*** (.001)
HML	.003*** (.001)	.004*** (.001)	.003*** (.001)	.002*** (.001)	.002*** (.001)	-.003*** (.001)	.001 (.001)	-9.40 <sup>-5</sup> (.001)	.002 (.001)
RMW	.002*** (.001)	-2.54 <sup>-4</sup> (.001)	.005*** (.001)	-.002* (.001)	.004*** (.001)	-.001 (.001)	-.001 (.001)	-.009*** (.002)	-.001 (.001)
CMA	-.001 (.001)	-.003*** (.001)	-.006*** (.001)	-.001 (.001)	-.006*** (.001)	.005*** (.001)	-.008*** (.001)	.010*** (.002)	8.45 <sup>-5</sup> (.001)
MOM	.001*** (3.21 <sup>-4</sup> )	-.001*** (3.36 <sup>-4</sup> )	-4.02 <sup>-4</sup> (.001)	-.002*** (.001)	-.002*** (.001)	-.004*** (.001)	-4.84 <sup>-4</sup> (.001)	-.006*** (.001)	-.003*** (.001)
N	3,543	3,543	3,543	3,543	3,543	1,978	3,543	2,170	3,259.12
Log Likelihood	9,503.96	9,165.78	8,266.73	7,797.32	8,093.68	5,126.29	6,974.64	4,606.13	
Wald	2,270.89	10,165.73	2,066.74	2,906.59	2,276.83	315.98	2,051.71	1,626.65	

Note: Appropriate market excess rate of return calculated from the daily adjusted close, less the daily 3-Month daily US Treasury rate. Commodity excess return is Brent Crude return, less the daily 3-Month daily US Treasury rate. Natural Gas excess return is Henry Hub daily return, less the daily 3-Month daily US Treasury rate. \*\*\* statistically significant at .01. \*\* statistically significant at .05. \* statistically significant at .10.

Source: See Table 4.



**Table 11, Equipment & Services Generalized Autoregressive Conditions Heteroskedasticity Models**

	<i>Baker Hughes</i>	<i>Fluor</i>	<i>Halliburton</i>	<i>Helmerich &amp; Payne</i>	<i>Nabors Drilling</i>	<i>National Oilwell Varco</i>	<i>Nextier</i>	<i>Patterson Drilling</i>	<i>Precision Drilling</i>
Intercept	-1.19 <sup>-4</sup> (2.70 <sup>-4</sup> )	-1.02 <sup>-4</sup> (2.08 <sup>-4</sup> )	6.46 <sup>-5</sup> (2.51 <sup>-4</sup> )	.011*** (.004)	-1.90 <sup>-4</sup> (3.80 <sup>-4</sup> )	-1.12 <sup>-4</sup> (2.87 <sup>-4</sup> )	-.001 (.001)	-2.50 <sup>-7</sup> (3.68 <sup>-4</sup> )	-1.92 <sup>-4</sup> (4.08 <sup>-4</sup> )
S & P 500	1.03*** (.026)	1.24*** (.027)	1.06*** (.024)	.620** (.266)	1.13*** (.037)	1.09*** (.030)	1.37*** (.093)	1.11*** (.035)	.979*** (.041)
Brent	.038*** (.011)	.120*** (.015)	.094*** (.015)	.052 (.140)	.130*** (.024)	.082*** (.015)	.228 (.030)	.113*** (.020)	.181*** (.025)
Natural Gas	.009 (.008)	.012*** (.004)	.003 (.007)	.009 (.102)	.022*** (.008)	.010 (.007)	.003 (.018)	.007 (.009)	.010 (.010)
Conventional Gas	.059*** (.012)	-.031*** (.012)	.060*** (.013)	-.073 (.177)	.050** (.021)	.051*** (.016)	-.087** (.044)	.059*** (.021)	.055** (.022)
Diesel	.151*** (.024)	.032 (.029)	.191*** (.026)	-.160 (.392)	.261*** (.033)	.173*** (.032)	.420*** (.105)	.253*** (.039)	.297*** (.041)
Jet Fuel	.063*** (.021)	.035 (.027)	.044** (.023)	.411 (.332)	.132*** (.032)	.046 (.030)	.038 (.109)	.091** (.036)	.106*** (.039)
SMB	.003*** (.005)	.004*** (4.19 <sup>-4</sup> )	.003*** (.001)	3.09 <sup>-4</sup> (.007)	.005*** (.001)	.003*** (.001)	.014*** (.002)	.005*** (.001)	.006*** (.001)
HML	.003*** (.001)	.001 (.001)	.002*** (.001)	-.005 (.008)	.002*** (.001)	.004*** (.001)	.002 (.002)	.004*** (.001)	.001 (.001)
RMW	.002** (.001)	-.005*** (.001)	-1.11 <sup>-4</sup> (.001)	.007 (.011)	-.004*** (.001)	3.24 <sup>-4</sup> (.001)	-.013*** (.003)	4.22 <sup>-4</sup> (.001)	-.004*** (.001)
CMA	.013*** (.001)	-.002*** (.001)	.001* (.001)	.035** (.015)	.002* (.001)	-.001 (.001)	.007** (.004)	-.001 (.001)	.003* (.001)
MOM	-.001*** (3.51 <sup>-4</sup> )	-2.27 <sup>-4</sup> (3.03 <sup>-4</sup> )	-.002*** (3.21 <sup>-4</sup> )	-.004 (.005)	-.003*** (.001)	-.002*** (3.72 <sup>-4</sup> )	-.009*** (.001)	-.003*** (.001)	-.005*** (.001)
N	3,543	3,543	3,543	1,919	3,543	3,543	892	3,543	3,543
Log Likelihood	9,298.55	9,104.04	9,515.86	840.03	8,012.75	9,108.01	1,871.92	8,365.18	7,870.76
Wald	5,973.83	6,368.55	5,927.24	35.99	3,049.43	4,637.42	1,448.58	3,455.76	4,119.13

**Table 11, Continued. Equipment & Service Generalized Autoregressive Conditions Heteroskedasticity Models**

	<i>Schlumberger</i>	<i>TechniFMC</i>	<i>Tidewater</i>	<i>Total</i>
Intercept	-2.94 <sup>-4</sup> (2.01 <sup>-4</sup> )	7.67 <sup>-5</sup> (2.81 <sup>-4</sup> )	-4.82 <sup>-4</sup> * (2.71 <sup>-4</sup> )	.001 (.001)
S & P 500	1.04*** (.019)	1.07*** (.030)	.855*** (.029)	1.05*** (.055)
Brent	.083*** (.013)	.080*** (.016)	.032* (.019)	.103*** (.018)
Natural Gas	.005 (.004)	.001 (.006)	.031* (.019)	.010 (.016)
Conventional Gas	.070*** (.010)	.067*** (.015)	-.011* (.001)	.022 (.029)
Diesel	.133*** (.022)	.134*** (.030)	.079*** (.016)	.164*** (.066)
Jet Fuel	.026 (.020)	.061** (.030)	.179*** (.038)	.103* (.061)
SMB	.002*** (4.09 <sup>-4</sup> )	.005*** (.001)	.005*** (.001)	.005*** (.002)
HML	.003*** (4.42 <sup>-4</sup> )	.003*** (.001)	.001* (.001)	.002 (.002)
RMW	3.73 <sup>-4</sup> (.001)	.001 (.001)	.002** (.001)	-.001 (.002)
CMA	.001 (.001)	2.30 <sup>-4</sup> (.001)	-.003*** (.001)	.004* (.002)
MOM	-.002*** (2.94 <sup>-4</sup> )	-.001** (3.74 <sup>-4</sup> )	-.002*** (3.79 <sup>-4</sup> )	-.003 (.001)
N	3,543	3,543	3,543	
Log Likelihood	10,222.60	9,262.51	8,333.19	3,186.75
Wald	9,520.39	4,458.97	2,743.08	

Note: Appropriate market excess rate of return calculated from the daily adjusted close, less the daily 3-Month daily US Treasury rate. Commodity excess return is Brent Crude return, less the daily 3-Month daily US Treasury rate. Natural Gas excess return is Henry Hub daily return, less the daily 3-Month daily US Treasury rate. \*\*\* statistically significant at .01. \*\* statistically significant at .05. \* statistically significant at .10.

Source: See Table 4.

Table 12 continued, Integrated Equipment &amp; Service Generalized Autoregressive Conditions Heteroskedasticity Models

	<i>BP</i>	<i>Chevron</i>	<i>ENI</i>	<i>Exxon</i>	<i>Conoco Phillips</i>	<i>Hess</i>	<i>Murphy Oil</i>	<i>Petrobras</i>
Intercept	-7.26 <sup>-5</sup> (1.81 <sup>-4</sup> )	-1.11 <sup>-5</sup> (1.49 <sup>-4</sup> )	-2.40 <sup>-4</sup> (1.84 <sup>-4</sup> )	-2.15 <sup>-4*</sup> (1.24 <sup>-4</sup> )	4.54 <sup>-5</sup> (1.82 <sup>-4</sup> )	1.03 <sup>-4</sup> (2.37 <sup>-4</sup> )	4.26 <sup>-4</sup> (.001)	-2.80 <sup>-4</sup> (3.06 <sup>-4</sup> )
S & P 500	.824*** (.015)	.912*** (.014)	.977*** (.016)	.867*** (.013)	.897*** (.019)	1.11*** (.024)	.945*** (.022)	1.20*** (.030)
Brent	.095*** (.010)	.035*** (.008)	.077*** (.008)	.025*** (.001)	.089*** (.010)	.087*** (.014)	.105*** (.015)	.092*** (.020)
Natural Gas	-.009*** (.003)	.003 (.004)	-.002 (.004)	.005* (.003)	-.005 (.005)	.004 (.006)	.002 (.006)	-.013* (.007)
Conventional Gas	.028*** (.009)	.031*** (.007)	.022** (.001)	.018*** (.006)	.051*** (.010)	.071*** (.013)	.062*** (.015)	.063*** (.017)
Diesel	.125*** (.016)	.110*** (.014)	.082*** (.017)	.082*** (.013)	.125*** (.020)	.212*** (.024)	.152*** (.024)	.104** (.041)
Jet Fuel	.014 (.017)	.014 (.013)	.034** (.015)	.018 (.011)	.046** (.019)	.050** (.024)	.113*** (.024)	.113*** (.040)
SMB	-2.94 <sup>-4</sup> (3.20 <sup>-4</sup> )	-.001*** (2.55 <sup>-4</sup> )	3.62 <sup>-4</sup> (3.34 <sup>-4</sup> )	-.001*** (2.36 <sup>-4</sup> )	-4.43 <sup>-4</sup> (3.37 <sup>-4</sup> )	.001** (.001)	.002*** (4.04 <sup>-4</sup> )	.001 (.001)
HML	1.49 <sup>-4</sup> (3.38 <sup>-4</sup> )	.001*** (2.85 <sup>-4</sup> )	.001*** (3.95 <sup>-4</sup> )	2.37 <sup>-4</sup> (2.42 <sup>-4</sup> )	.003*** (3.98 <sup>-4</sup> )	.002*** (.001)	.003*** (3.92 <sup>-4</sup> )	.001 (.001)
RMW	-4.27 <sup>-4</sup> (4.18 <sup>-4</sup> )	.002*** (3.67 <sup>-4</sup> )	-.001 (.001)	.003*** (3.49 <sup>-4</sup> )	.002*** (.001)	-.001 (.001)	.001** (.001)	.003*** (.001)
CMA	.004*** (.001)	.004*** (.001)	.016*** (.001)	.014*** (.001)	.013*** (.001)	.017*** (.001)	.016*** (2.55 <sup>-7</sup> )	1.67 <sup>-5</sup> (.001)
MOM	-.001*** (2.21 <sup>-4</sup> )	-.001** (1.86 <sup>-6</sup> )	-.001** (2.57 <sup>-4</sup> )	-.001*** (1.72 <sup>-4</sup> )	-.001** (2.46 <sup>-4</sup> )	-.003*** (3.39 <sup>-4</sup> )	-2.41 <sup>-7</sup> (2.55 <sup>-7</sup> )	-.003*** (4.33 <sup>-4</sup> )
N	3,543	3,543	3,543	3,544	3,515	3,543	3,543	3,604
Log Likelihood	10,798.96	11,580.14	10,624.37	11,889.31	10,582.58	9,502.25	9,314.49	8,497.81
Wald	15,663.62	11,472.56	9,193.38	8,323.45	7,876.22	6,881.94	7,908.50	5,141.71

Note: Appropriate market excess rate of return calculated from the daily adjusted close, less the daily 3-Month daily US Treasury rate. Commodity excess return is Brent Crude return, less the daily 3-Month daily US Treasury rate. Natural Gas excess return is Henry Hub daily return, less the daily 3-Month daily US Treasury rate. \*\*\* statistically significant at .01. \*\* statistically significant at .05. \* statistically significant at .10.

Source: See Table 4.

	<i>PetroChina</i>	<i>Royal Dutch Shell</i>	<i>Total, SA</i>	<i>Total</i>
Intercept	-4.49 <sup>-4</sup> ** (2.26 <sup>-4</sup> )	-1.03 <sup>-4</sup> (1.63 <sup>-4</sup> )	-6.00 <sup>-5</sup> (1.70 <sup>-4</sup> )	-3.03 <sup>-5</sup> (2.66 <sup>-4</sup> )
S & P 500	.998*** (.022)	.841*** (.016)	.976*** (.014)	.959*** (.017)
Brent	.052*** (.012)	.037 (.004)	.078*** (.009)	.070*** (.010)
Natural Gas	-.001 (.001)	-.001 (.004)	-.003 (.003)	-.002 (.004)
Conventional Gas	.009 (.011)	.008 (.006)	.024*** (.008)	.035*** (.009)
Diesel	.110*** (.015)	.205*** (.012)	.103*** (.016)	.128*** (.019)
Jet Fuel	.043*** (.011)	-.007 (.010)	.027* (.015)	.042*** (.018)
SMB	2.61 <sup>-5</sup> (3.96 <sup>-4</sup> )	-2.87 <sup>-4</sup> (3.21 <sup>-4</sup> )	-1.56 <sup>-4</sup> (3.04 <sup>-4</sup> )	1.10 <sup>-4</sup> (.001)
HML	.001 (.001)	.001* (3.64 <sup>-4</sup> )	.001*** (3.44 <sup>-4</sup> )	.001 (.004)
RMW	-1.34 <sup>-5</sup> (.001)	.001 (.001)	.001** (.001)	.001 (.001)
CMA	.001 (.001)	.005*** (.001)	.003*** (.001)	.009*** (.001)
MOM	-.002*** (2.80 <sup>-4</sup> )	-.001*** (2.37 <sup>-4</sup> )	-.001*** (2.30 <sup>-3</sup> )	-.001*** (3.43 <sup>-4</sup> )
N	3,543	3,543	3,543	3,546.09
Log Likelihood	9,909.62	10,918.11	11,033.58	
Wald	5,942.00	7,376.27	13,249.01	

**Table 13, Refining and Marketing Generalized Autoregressive Conditions Heteroskedasticity Models**

	<i>Holly Frontier</i>	<i>Marathon Petroleum</i>	<i>PBF</i>	<i>Valero</i>	<i>Total</i>
Intercept	.001 (3.49 <sup>-4</sup> )	2.97 <sup>-4</sup> (3.76 <sup>-4</sup> )	1.45 <sup>-4</sup> (.001)	3.77 <sup>-4</sup> (2.74 <sup>-4</sup> )	.001 (.001)
S & P 500	.955*** (.032)	1.05*** (.034)	1.40*** (.056)	1.08*** (.025)	1.12*** (.037)
Brent	.006 (.020)	.044** (.022)	-.064** (.031)	.006 (.026)	-.002 (.025)
Natural Gas	-.007 (.009)	-.017* (.009)	-.019 (.013)	-.002 (.007)	-.011 (.001)
Conventional Gas	.124*** (.017)	.068*** (.015)	.114*** (.025)	.105*** (.013)	.103*** (.018)
Diesel	.144*** (.035)	.043 (.041)	.172*** (.061)	.090*** (.030)	.112*** (.035)
Jet Fuel	-.002 (.033)	.020 (.040)	-.020 (.061)	-.011 (.027)	-.003 (.040)
SMB	.005*** (.001)	.003*** (.001)	.006*** (.001)	.004*** (.001)	.005*** (.001)
HML	.003*** (.001)	.005*** (.001)	.005*** (.001)	.004*** (.001)	.004*** (.001)
RMW	.002* (.001)	-.001 (.001)	.003* (.002)	.002** (.001)	.002 (.001)
CMA	-.003** (.001)	-.003* (.002)	.013*** (.002)	-.005*** (.001)	.001 (.002)
MOM	1.79 <sup>-4</sup> (.001)	-.001** (.001)	-.002** (.001)	.001 (3.91 <sup>-4</sup> )	-.001 (3.48 <sup>-4</sup> )
N	3,543	2,285	1,922	3,543	2,823.25
Log Likelihood	8,505.70	5,885.42	4,317.49	9,291.37	
Wald	2,593.60	2,583.44	1,542.43	3,836.38	

**Table 14, Transportation and Pipeline Generalized Autoregressive Conditions Heteroskedasticity Models**

	<i>Cheniere</i>	<i>Kinder Morgan</i>	<i>OneOK</i>	<i>Whiting</i>	<i>Total</i>
Intercept	.001** (3.30 <sup>-4</sup> )	-5.84 <sup>-5</sup> (2.38 <sup>-4</sup> )	.001*** (1.70 <sup>-4</sup> )	4.24 <sup>-4</sup> (3.00 <sup>-4</sup> )	.001 (2.53 <sup>-4</sup> )
S & P 500	.944*** (.035)	.811*** (.022)	.877*** (.013)	1.26*** (.027)	.973*** (.024)
Brent	-.015 (.021)	.020* (.012)	.044*** (.010)	.181*** (.016)	.058 (.013)
Natural Gas	-.002 (.007)	.008 (.005)	.015*** (.005)	.002 (.008)	.006 (.006)
Conventional Gas	.040** (.019)	.018 (.015)	.057*** (.008)	.105*** (.019)	.055*** (.015)
Diesel	.116*** (.039)	.073*** (.026)	.056*** (.014)	.270*** (.038)	.129*** (.029)
Jet Fuel	.053 (.040)	-.004 (.030)	.028* (.015)	.070** (.035)	.037 (.030)
SMB	.004*** (.001)	.001 (.001)	.002*** (3.05 <sup>-4</sup> )	.006*** (.001)	.003*** (.001)
HML	.001 (.001)	.001* (.001)	-3.35 <sup>-5</sup> (3.57 <sup>-4</sup> )	.001 (.001)	.001 (.001)
RMW	-.009*** (.001)	-.005*** (.001)	.004*** (4.25 <sup>-4</sup> )	.001* (.001)	-.002*** (.001)
CMA	.001 (.001)	.004*** (.001)	.006*** (.001)	-.008*** (.001)	.001 (.001)
MOM	-.001** (.001)	-.002*** (2.93 <sup>-4</sup> )	4.09 <sup>-4</sup> * (2.28 <sup>-4</sup> )	-.002*** (.001)	-.001* (.001)
N	3,543	2,435	3,543	3,543	3266
Log Likelihood	7,820.07	7,189.15	10,134.75	7,374.51	



Wald	1,714.72	6,677.78	10,901.31	7,138.30
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Three patterns emerge when evaluating oil and gas producer and consumer sectors with project risk variation. First, when estimating multi-factor models, a leading concern is equity market excess return variation, and across sectors, upstream oil and gas producer returns are positively related to equity market risk (Tables 9 through 13). Oil and gas sector return coefficients vary with geographic proximity to oil production (Carson, 2022a). Among oil and gas producers, refining & marketing firms have the greatest equity risk, followed by exploration & production and equipment & service, transportation & pipeline, Integrated, and transportation & pipeline. As an industry sector, refining & marketing has the greatest risk across downstream producers (Table 19), and there is asymmetric risk between when refiners & marketers purchase crude and when refined conventional gas, diesel, and jet fuel products are delivered to downstream consumers (Chandler, 1977, p. 254; Chandler, 1990, pp. 92-105). Exploration & production and equipment & service firms are closest to oil and gas production, and equity return variation is high for upstream equity market variation compared to downstream firms (Carson, 2022a). Downstream oil and gas consumer equity market risk is greatest among rail, tire manufacturing, and air freight. Among downstream oil and gas consumers, rail companies have the highest average equity risk, followed by manufactures, air, and ground freight carriers. Downstream oil and gas consumer equity market risk is the lowest for ground freight, and downstream consumer equity market risk, as a group, is greater than oil and gas producers. Subsequently, firms closer to physical proximity to oil extraction have greater equity market risk and returns, and downstream refineries & marketers bear asymmetric risk between purchase and delivery dates, while downstream consumers have the greatest equity market risk.

**Table 15, Airlines Generalized Autoregressive Conditions Heteroskedasticity Models**

	<i>Alaska</i>	<i>Allegiant</i>	<i>American</i>	<i>Atlas</i>	<i>Cathay</i>	<i>Chinese Southern</i>	<i>Jet Blue</i>	<i>Ryan Air</i>	<i>Singapore</i>
Intercept	.001 (2.89 <sup>-4</sup> )	.001* (3.56 <sup>-6</sup> )	1.28 <sup>-4</sup> (4.25 <sup>-4</sup> )	2.21 <sup>-4</sup> (3.26 <sup>-3</sup> )	1.42 <sup>-4</sup> (3.07 <sup>-4</sup> )	3.18 <sup>-4</sup> (.001)	3.34 <sup>-4</sup> (3.27 <sup>-4</sup> )	.001* (2.94 <sup>-4</sup> )	-1.48 <sup>-4</sup> (2.31 <sup>-4</sup> )
S & P 500	1.24*** (.029)	.911*** (.029)	1.50*** (.038)	1.19*** (.032)	.574*** (.030)	1.25*** (.041)	1.20*** (.018)	.879*** (.026)	.482*** (.012)
Brent	-.086*** (.017)	-.100*** (.021)	-.109*** (.025)	-.026* (.015)	.002 (.141)	-.029 (.021)	-.086*** (.018)	-.054*** (.016)	.104*** (.012)
Natural Gas									
Conventional Gas									
Diesel									
Jet Fuel	-.136*** (.018)	-.068*** (.022)	-.178*** (.023)	.028* (.015)	-.005 (.017)	-.009 (.025)	-.156*** (.016)	-.029 (.018)	-.018 (.016)
SMB	.009*** (.001)	.008 (.001)	.008*** (.001)	.010*** (.001)	.001 (.001)	.001* (.001)	.010*** (.001)	.003*** (.001)	-.001 (.001)
HML	.004*** (.001)	.002*** (.001)	.005*** (.001)	.004*** (.001)	-.001 (.001)	-.001 (.001)	.004*** (.001)	.001* (.001)	-.002*** (.001)
RMW	.005*** (.001)	.006*** (.001)	.002 (.001)	.001 (.001)	-.001 (.001)	-.001 (.001)	.002** (.001)	.003*** (.001)	-.002*** (.001)
CMA	.002** (.001)	-.001 (.001)	-.001 (.002)	.001 (.001)	-.001 (.001)	-.001 (.002)	.001 (.001)	.001 (.001)	1.59 <sup>-4</sup> (.001)
MOM	.001** (4.16 <sup>-4</sup> )	.001*** (.001)	-.004** (.001)	-.001** (4.36 <sup>-4</sup> )	-.002 (4.20 <sup>-4</sup> )	-.002*** (.001)	-.001 (.002)	-.001*** (.001)	9.42 <sup>-4</sup> (3.57 <sup>-4</sup> )
N	3,542	3,421	3,543	3,543	3,543	3,543	3,543	3,543	2,642
Log Likelihood	8,816.48	8,199.96	7,503.71	8,252.54	8,878.72	7,668.96	8,543.41	9,154.14	7,549.93
Wald	2,614.84	1,253.31	2,171.08	3,398.35	559.99	1,472.36	2,938.08	1,732.29	698.29

**Table 15, Airlines Generalized Autoregressive Conditions Heteroskedasticity Models**

	<i>Skywest</i>	<i>Southwest</i>	<i>Spirit</i>	<i>United</i>	<i>UPS</i>	<i>Total</i>
Intercept	3.69 <sup>-4</sup> (3.25 <sup>-5</sup> )	.001** (2.50 <sup>-4</sup> )	4.66 <sup>-4</sup> (4.41 <sup>-4</sup> )	.001 (3.62 <sup>-4</sup> )	-1.92 <sup>-5</sup> (1.20 <sup>-4</sup> )	.001 (3.15 <sup>-4</sup> )
S & P 500	1.16*** (.032)	1.02*** (.022)	1.25*** (.050)	1.29*** (.032)	.843*** (.011)	1.06*** (.029)
Brent	-.055*** (.018)	-.056*** (.012)	-.069** (.030)	-.101*** (.020)	.010 (.007)	-.046*** (.018)
Natural Gas						
Conventional Gas						
Diesel						
Jet Fuel	-.111*** (.012)	.101*** (.010)	-.084*** (.032)	-.099*** (.015)	-.047*** (.007)	-.058*** (.018)
SMB	.012*** (.001)	.004*** (4.10 <sup>-4</sup> )	.013*** (.001)	.007*** (.001)	.001*** (1.59 <sup>-4</sup> )	.006*** (.001)
HML	.004*** (.001)	.002*** (4.09 <sup>-4</sup> )	.005*** (.001)	.005*** (.001)	-.001** (2.43 <sup>-4</sup> )	.002*** (.001)
RMW	.003*** (.001)	.001 (.001)	.007*** (.001)	.002 (.001)	.002*** (2.96 <sup>-4</sup> )	.002*** (.001)
CMA	-.001 (.001)	.001 (.001)	-.003* (.002)	9.29 <sup>-5</sup> (.001)	.003*** (3.98 <sup>-4</sup> )	6.89 <sup>-5</sup> * (.001)
MOM	-.001** (4.20 <sup>-4</sup> )	-.001*** (2.98 <sup>-4</sup> )	.001 (.001)	.001 (.001)	-.001*** (1.83 <sup>-4</sup> )	-.001 (.001)
N	3,543	3,543	2,304	3,545	3,543	
Log Likelihood	8,516.36	9,553.72	5,313.47	7,785.63	11,406.43	
Wald	2,752.55	4,169.53	1,267.40	2,037.77	10,710.41	

Table 16, Freight Generalized Autoregressive Conditions Heteroskedasticity

	<i>Covenant</i>	<i>Forward Air</i>	<i>Heartland</i>	<i>JB Hunt</i>	<i>Knight- Swift</i>	<i>Landster</i>	<i>Marten Express</i>	<i>Old Dominion</i>	<i>PAM Transportation</i>
Intercept	.001 (.001)	1.28 <sup>-4</sup> (2.29 <sup>-4</sup> )	1.14 <sup>-4</sup> (2.45 <sup>-4</sup> )	2.84 <sup>-4</sup> (2.10 <sup>-4</sup> )	1.53 <sup>-4</sup> (2.76 <sup>-4</sup> )	1.76 <sup>-4</sup> (1.98 <sup>-4</sup> )	3.41 <sup>-4</sup> (2.86 <sup>-4</sup> )	.001*** (2.12 <sup>-4</sup> )	.001 (.001)
S & P 500	.962*** (.043)	1.01*** (.020)	.878*** (.018)	.984*** (-.017)	.995*** (.022)	.904*** (.018)	.993*** (.021)	1.16*** (.018)	.673*** (.034)
Brent	.011 (.030)	-.016 (.012)	-.040*** (.011)	-.013 (.012)	-.031** (.015)	-.009 (.012)	-.028 (.018)	.002 (.012)	-.013 (.027)
Natural Gas									
Conventional Gas									
Diesel	.010 (.029)	-.021 (.014)	-.052*** (.012)	-.033** (.014)	-.050*** (.017)	-.017 (.012)	-.035* (.019)	-.058*** (.013)	-.025 (.029)
Jet Fuel									
SMB	.010*** (.001)	.011*** (3.74 <sup>-4</sup> )	.009*** (3.76 <sup>-4</sup> )	.006*** (3.44 <sup>-4</sup> )	.008*** (4.06 <sup>-4</sup> )	.007*** (3.56 <sup>-5</sup> )	.013*** (.001)	.009*** (3.92 <sup>-4</sup> )	.007*** (6.78 <sup>-4</sup> )
HML	.004*** (.001)	.001* (4.39 <sup>-4</sup> )	.009*** (3.76 <sup>-4</sup> )	3.04 <sup>-4</sup> (4.05 <sup>-4</sup> )	-.002*** (.001)	-.001 (4.33 <sup>-4</sup> )	.001 (.001)	-.001 (.001)	-.001 (.001)
RMW	.006*** (.001)	.005*** (.001)	-.001* (4.19 <sup>-4</sup> )	.004*** (.001)	.005*** (.001)	.004*** (.001)	.007*** (.001)	.004*** (.001)	.001 (.001)
CMA	-.002 (.002)	.001* (.001)	.004*** (.001)	.004*** (.001)	.003*** (.001)	.004*** (.001)	.002* (.001)	.003*** (.001)	.005*** (.002)
MOM	-.002 (.001)	-.001** (3.08 <sup>-4</sup> )	-.001** (2.95 <sup>-4</sup> )	-3.43 <sup>-4</sup> (2.71 <sup>-4</sup> )	-.002*** (3.42 <sup>-4</sup> )	-4.29 <sup>-4</sup> (2.80 <sup>-4</sup> )	.001 (3.80 <sup>-4</sup> )	4.30 <sup>-4</sup> (3.48 <sup>-4</sup> )	.001 (.001)
N	3.543	3,543	3,543	3,543	3,543	3,543	3,543	3,543	3,543
Log Likelihood	7,087.91	9,836.13	9,999.46	10,320.47	9,528.92	10,326.21	9,059.45	9,621.85	7,419.52
Wald	1,281.22	6,285.90	4,605.47	4,692.47	3,388.45	4,434.07	6,491.25	5,028.73	661.45

Table 16 continued, Freight Generalized Autoregressive Conditions Heteroskedasticity Models

	<i>Penske</i>	<i>Road Runner</i>	<i>Ryder</i>	<i>Saia Transportation</i>	<i>Schneider</i>	<i>Werner</i>	<i>XPO Logistics</i>	<i>YRC Holland</i>	<i>Total</i>
Intercept	2.43 <sup>-4</sup> (2.57 <sup>-4</sup> )	4.21 <sup>-4</sup> (.001)	2.16 <sup>-5</sup> (2.48 <sup>-4</sup> )	.001 (3.64 <sup>-4</sup> )	-1.39 <sup>-4</sup> (.001)	1.70 <sup>-4</sup> (2.96 <sup>-4</sup> )	.001** (4.15 <sup>-4</sup> )	-1.04 <sup>-4</sup> (.001)	3.67 <sup>-4</sup> (.001)
S & P 500	1.22*** (.025)	1.13*** (.037)	1.26*** (.021)	1.15*** (.031)	.843*** (.042)	.975*** (.016)	.730*** (.037)	.190*** (.072)	.945*** (.026)
Brent	.034** (.014)	-.056* (.029)	.008 (.014)	-.038*** (.014)	-.049*** (.022)	-.038*** (.013)	.070*** (.021)	.037 (.038)	-.010 (.019)
Natural Gas									
Conventional Gas									
Diesel	-.062*** (.016)	.050 (.032)	-.020 (.016)	.004 (.020)	.110*** (.034)	-.043*** (.015)	.006 (.027)	-.030 (.045)	-.016 (.021)
Jet Fuel									
SMB	.011*** (.001)	.011*** (.001)	.008*** (4.11 <sup>-4</sup> )	.012*** (.001)	.007*** (.001)	.008*** (4.04 <sup>-4</sup> )	.009*** (.001)	-3.84 <sup>-4</sup> (.001)	.009*** (.001)
HML	.003*** (.001)	.001 (.001)	.002*** (.001)	.003*** (.001)	-.003*** (.001)	-.001*** (.001)	.002** (.001)	-.004*** (.001)	.001 (.001)
RMW	.005*** (.001)	.007*** (.001)	.006*** (.001)	.004*** (.001)	.005*** (.002)	.005*** (.001)	.002 (.001)	-.009*** (.002)	.004*** (.001)
CMA	.003*** (.001)	.005*** (.002)	.003*** (.001)	-4.47 <sup>-4</sup> (.001)	.004** (.002)	.005*** (.001)	-.007*** (.001)	.003 (.002)	.022* (.001)
MOM	-.002*** (3.57 <sup>-4</sup> )	-.004*** (.001)	-.002*** (2.91 <sup>-4</sup> )	-7.01 <sup>-5</sup> (4.22 <sup>-4</sup> )	.001 (.001)	-.001 (3.11 <sup>-4</sup> )	.002*** (.001)	-.003*** (.001)	-.001 (.001)
N	3,543	2,564	3,543	3,543	839	3,543	3,543	3,543	
Log Likelihood	9,383.40	5,230.36	9,705.63	8,368.65	2,253.79	9,879.15	7,717.80	5,187.19	
Wald	4,597.58	5,602.83	5,170.89	3,324.96	765.38	5,560.97	1,057.16	56.27	



Log Likelihood	12,360.3	11,167.7	10,220.9	10,469.12	10,144.32	9,695.17	10,428.2	10,766.85	9,925.69
Wald	18,923.60	6.646.59	9,938.45	7,388.38	5,471.43	8,530.19	6,109.53	5,963.79	8,307.84



**Table 18, Tire Manufacturer Generalized Autoregressive Conditions Heteroskedasticity Models**

	<i>Bridgestone</i>	<i>Cooper</i>	<i>Goodyear</i>	<i>Michelin</i>	<i>Total</i>
Intercept	-2.04 <sup>-4</sup> (2.48 <sup>-4</sup> )	.001*** (3.27 <sup>-4</sup> )	1.67 <sup>-4</sup> (3.06 <sup>-4</sup> )	3.12 <sup>-5</sup> (2.66 <sup>-4</sup> )	2.49 <sup>-4</sup> (2.96 <sup>-4</sup> )
S & P 500	.700*** (.024)	1.04*** (.032)	1.47*** (.024)	1.11*** (.027)	1.08*** (.027)
Brent	-.017* (.009)	-.064*** (.016)	-.018 (.013)	-.002 (.012)	-.025** (.013)
Natural Gas					
Conventional Gas					
Diesel					
Jet Fuel					
SMB	.001 (4.28 <sup>-4</sup> )	.011 (.001***)	.008*** (.001)	.002*** (.001)	.006*** (.001)
HML	9.95 <sup>-5</sup> (.001)	.004*** (.001)	.003*** (.001)	.002*** (.001)	.002** (.001)
RMW	-.001 (.001)	.005*** (.001)	.006*** (.001)	.002* (.001)	.003*** (.001)
CMA	-.001 (.001)	.004*** (.001)	.003*** (.001)	-.001 (.001)	.001 (.001)
MOM	-.001*** (3.74 <sup>-4</sup> )	-.002*** (.001)	-.004*** (3.98 <sup>-4</sup> )	-.001*** (4.25 <sup>-4</sup> )	-.001*** (.001)
N	2,656	3,543	3,543	2,642	3,096
Log Likelihood	7,650.43	8,233.10	8,720.02	7,389.65	
Wald	1,151.95	2,176.76	9,230.90	2,491.11	

Second, upstream exploration & production and equipment & services oil and gas producers have the greatest commodity market risk, while midstream and downstream oil producer returns vary little with commodity risk (Table 15 through 18). Downstream producers are compensated per barrel transported or refined, and because their values are not directly tied to the price of crude, downstream transportation & pipeline and refining & marketing are not systematically related to commodity returns (Chandler, 1977, pp. 254-258; Chandler, 1990, pp. 92-104). For equity and commodity risk, upstream oil and gas producers take on greater risk in equity and commodity markets compared to downstream oil and gas producers (Carson, 2020; Carson, 2022a). Individual oil consumer commodity market excess return variations are also positively related to commodity market risk (Tables 15 through 18) and indicates broader relationships with macroeconomic performance associated with the larger economy.

A few downstream consumers have negative equity and commodity coefficients, indicating systematic inverse relationships with upstream producer returns, where crude is a primary input in downstream oil and gas production. With oil as an input to downstream airlines, freight, railroads, and tire manufacturing, consumer returns decreased when upstream oil prices and returns increased, indicating there are hedging opportunities between downstream consumers and oil production (Perry, 1989; McGee and Bassett, 1976). Integrated producers are major jet fuel refiners, and around 10 percent of refined crude is aviation fuel (EIA, 2021). There is limited upstream oil and gas commodity return variation with aviation fuels. Aviation fuel is a downstream domestic airline travel input, and airline returns are negatively related to returns to aviation fuel returns (Table 15). Subsequently, commodity return variation is positively but less related to commodity and distillate market risk, and domestic air travel is the

only downstream industrial consumer that consistently has a negative relationship with aviation fuel.

Diesel, natural gas, commercial, and aviation fuels are related to upstream producer returns, and upstream exploration & production and equipment & service firms have the greatest risk with diesel return variation. Integrated majors and downstream transportation & pipeline and refining & marketing returns are also positively related to diesel variation by more than conventional gas and aviation fuel derivatives. Upstream equipment & services oil and gas producers are also positively related to conventional gas returns, and through its position in oil and gas production, downstream refiners bear the greatest conventional gas risk. However, downstream refiners bear risk by delivering refined conventional gas to down stream consumers, who are paid for the number of barrels refined, which does not directly vary with the price of crude but with refined distillates, such as conventional gas.

Table 19, Combined Generalized Autoregressive Conditions Heteroskedasticity Models

	<i>Exploration &amp; Production</i>	<i>Equipment &amp; Services</i>	<i>Integrated</i>	<i>Transportation &amp; Pipeline</i>	<i>Refining &amp; Marketing</i>	<i>Air</i>	<i>Freight</i>	<i>Rail</i>	<i>Tires</i>
Intercept	7.92 <sup>-5</sup> (4.13 <sup>-4</sup> )	.001 (.001)	-3.03 <sup>-5</sup> (2.66 <sup>-4</sup> )	.001 (2.53 <sup>-4</sup> )	.001 (.001)	.001 (3.15 <sup>-4</sup> )	3.67 <sup>-4</sup> (.001)	.001*** (1.80 <sup>-4</sup> )	2.49 <sup>-4</sup> (2.96 <sup>-4</sup> )
S & P 500	.941*** (.035)	1.05*** (.055)	.959*** (.017)	.973*** (.024)	1.12*** (.037)	1.06*** (.029)	.945*** (.026)	1.09*** (.017)	1.08*** (.027)
Brent	.091*** (.019)	.103*** (.018)	.070*** (.010)	.058 (.013)	-.002 (.025)	- (.018)	-.010 (.019)	.011 (.009)	-.025** (.013)
Natural Gas	.019*** (.008)	.010 (.016)	-.002 (.004)	.006 (.006)	-.011 (.001)				
Conventional Gas	.059*** (.023)	.022 (.029)	.035*** (.009)	.055*** (.015)	.103*** (.018)				
Diesel	.200*** (.036)	.164*** (.066)	.128*** (.019)	.129*** (.029)	.112*** (.035)		-.016 (.021)	.014 (.010)	
Jet Fuel	.040** (.034)	.103* (.061)	.042*** (.018)	.037 (.030)	-.003 (.040)	- (.018)			
SMB	.004*** (.001)	.005*** (.002)	1.10 <sup>-4</sup> (.001)	.003*** (.001)	.005*** (.001)	.006*** (.001)	.009*** (.001)	.003*** (3.31 <sup>-4</sup> )	.006*** (.001)
HML	.002 (.001)	.002 (.002)	.001 (.004)	.001 (.001)	.004*** (.001)	.002*** (.001)	.001 (.001)	.002** (.001)	.002** (.001)
RMW	-.001 (.001)	-.001 (.002)	.001 (.001)	-.002*** (.001)	.002 (.001)	.002*** (.001)	.004*** (.001)	.002* (.001)	.003*** (.001)
CMA	8.45 <sup>-5</sup> (.001)	.004* (.002)	.009*** (.001)	.001 (.001)	.001 (.002)	6.89 <sup>-5</sup> * (.001)	.022* (.001)	.003*** (.001)	.001 (.001)
MOM	-.003*** (.001)	-.003 (.001)	-.001*** (3.43 <sup>-4</sup> )	-.001* (.001)	-.001 (3.48 <sup>-4</sup> )	-.001 (.001)	-.001 (.001)	-1.65 <sup>-4</sup> (2.55 <sup>-4</sup> )	- (.001***)

N	3,259.12		3,546.09	3266	2,823.25		3,543	3,096
Log Likelihood		3,186.75						
Wald								

Third, because various downstream consumers use the commodity oil and its derivatives as inputs, there are inverse risk-return relationships for firm returns and distillates, and downstream consumer returns decrease when upstream producer returns increase. For example, oil and aviation fuels are inputs to the airline industry and may have negative returns between individual airline carrier returns, oil, and various derivatives (Tables 19). With various downstream producers, oil and aviation fuels are inputs in the airline industry and have negative returns between individual airline returns, oil, and various petroleum derivatives. However, negative equity return betas in downstream ground freight do not significantly affect trucking returns. As an industry, firms in ground freight consume considerable quantities of refined crude products, and downstream ground freight companies make contracts with refining & marketing suppliers to secure dependable, low-cost diesel supplies with quantity discounts. Crude returns are negatively related to tire manufacturing returns because synthetic rubber is created from crude oil, indicating that oil-based products are primary inputs to downstream production in various segments of downstream oil and gas dependent supply chains.

Equity and commodity markets are integrated in oil and gas pricing returns and reflect different responsiveness to oil and gas across upstream producers and downstream consumers. One means to assess risk across industries is the ratio of equity to commodity market coefficients. Larger equity to commodity return coefficient ratios indicate firm risk varies more with equity than commodity markets, whereas low ratios indicate firms' risk and returns vary more with commodity compared to equity markets. Ratios are partitioned across upstream oil and gas producers and downstream consumers. For oil and gas producers, the ratio of equity to commodity market risk is higher the further firms are from production. Equity-commodity market risk ratios are even greater for downstream consumer equity to commodity risk. Oil and

gas equity and commodity markets price risk such that upstream producers' equity to commodity market risk is lower than downstream consumers. Subsequently, oil and gas producer risk, reflects heterogeneous labor, infrastructure, and market conditions from oil and gas production to its end use consumption.

Other patterns are consistent with expectations. Upstream oil and gas producers have greater SMB than downstream consumers; however, downstream consumers have considerably larger size effects than oil and gas producers (Table 19). Besides refining & marketing, oil and gas producer returns are not related to the value effects, while downstream oil and gas consumers are positively related to the value effect. Transportation & pipeline is the only oil producer sector related to robust-minus-weak, where all downstream oil and gas consumer returns are positively related to robust-minus-weak. Conservative-minus-aggressive only affects Integrated and downstream rail.

Jensen's alpha varies across upstream producers and downstream consumers that is useful to indicate market efficiency, and markets are more efficient the closer Jensen's alpha is to zero (Fama and French, 2015, p. 3). Around 7.69 percent of exploration & production and 8.33 percent of equipment & services intercepts are zero and inefficiently priced. Nine percent of Integrated intercepts are inefficiently priced. No refining and marketing firms are efficiently priced, while 20 percent of transportation & pipeline firms are zero. Seven percent of airline equities are inefficient. Fifty-five percent of railroad stock equities are inefficient, while 25 percent of tire manufacturers face inefficient equity returns. Subsequently, equity markets may more efficiently price upstream exploration & production and equipment & service firms that are

closest to oil extraction, whereas further downstream transportation & pipeline and refining & marketing firms may be less efficiently priced.

## V. Conclusion

Few industries have as central role in industrial economics as the oil and gas industry that are used in aviation, ground freight, railroads, and tire manufacturing, and because of their energy density, hydrocarbons occupy a pivotal role in freight, manufacturing, and transportation. Equity, commodity, and distillate markets price returns that vary with equity and commodity market risks. To varying to degrees, equity markets positively price upstream and downstream oil and gas producer and consumer returns, and firms closer to oil and gas production have greater risk compared to downstream consumers. Downstream air and ground manufactures have negative return variations with their primary oil and gas input. Equity and commodity markets positively price oil and gas producer returns that vary with project risk and infrastructure, and upstream oil and gas producers have greater equity and commodity market risk. However, downstream consumer risk is inversely related to equity and commodity market risk, indicating potential factors of production and hedging opportunities. Moreover, upstream oil and gas producers interact with downstream oil and gas consumers are integrated, and risk and returns to upstream producers are considerably greater than downstream oil and gas consumers.



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