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A Comparable Analysis of How Regional Oil Supply Shocks Affect Petroleum Equity Prices

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ABSTRACT

This study examines how regional crude oil supply shocks affect the equity prices of large-cap oil companies compared to small/mid-cap exploration and production (E&P) companies. The event used in this paper as the regional supply shock is the Winter Storm Uri, the February 2021 Texas freeze that physically shut U.S. crude production and cut national weekly output by 1.1 million barrels per day, equaling the largest weekly decline on record at the time (U.S. Energy Information Administration [EIA], 2021). This experiment uses a single-factor market model that is estimated over 100 trading days and a six-session event window ($\tau = -1$ to $\tau = +4$). Abnormal returns were calculated for four large-caps (XOM, CVX, SHEL, TTE) and four small-and mid-cap firms (MUR, CDEV, TALO, WTI). During the first trading session after the freeze ($\tau = 0$, February 16, 2021), the small/mid-cap group had a mean abnormal return of +4.67% versus +3.06% (large-cap group) which was a differential of +1.60%. This is further significant under Welch's unequal-variances t-test ($t = 3.12$, $p = .021$). The differential did not continue as it reversed at $\tau = +2$ (−2.23%, p=.063) since oil production shut-ins were a counter to the benefit of higher crude prices for producers whose own wells were frozen. Event-window volatility for the small/mid-cap group was 2.07 times that of the large cap group (Brown–Forsythe W= 6.71, p=.013). Cumulative abnormal returns were more favorable to the small/mid-cap group (+11.85% vs. +8.65%), but the 3.2% differential was not significant (p=0.146). In summary, regional crude supply shocks ultimately do produce an immediate price differential that is more favorable towards smaller firms that are concentrated in upstream operations.

Keywords: event study, abnormal returns, oil supply shock, market capitalization, Winter Storm Uri, energy equities.

INTRODUCTION

1.1 Background

Crude oil is one of the most important commodities in the global economy, and disruptions to its supply can create pricing consequences that result from demand-driven price movements (Kilian, 2009). Equity investors treat publicly traded petroleum companies as a tool for expressing views on oil prices, and the

returns of oil and gas equities are strongly tied to the price of crude oil (Ramos & Veiga, 2011). Petroleum firms differ drastically in corporate scale, geographic diversification/operations, and their specific activity within the petroleum supply chain. These differences cause their share prices to respond differently to the same supply shock. Large-cap supermajors operate globally across upstream production, refining, and marketing; which essentially means a disruption in any single revenue-bearing region affects only a small fraction of their profit and assets. This results in changes in crude prices affecting their upstream and downstream operations in somewhat offsetting directions (Brealey, Myers, & Allen, 2019). Small-and mid-cap E&P firms often concentrate their operations in specific basins and derive their profits almost entirely from upstream production. This can carry a higher degree of operating and financial leverage, which can increase the systematic risk of their equity (Mandelker & Rhee, 1984).

The event that represents the regional supply shock in this experiment is the Winter Storm Uri. In mid-February 2021, the Uri winter storm greatly affected Texas and other neighboring southern states with widespread freezing and snow. The onslaught of the storm resulted in freezing wellheads, gathering lines, and electrical supply across the Permian Basin and other nearby reservoirs. According to the U.S. Energy Information Administration's weekly data, U.S. crude oil production fell by 1.1 million barrels per day to 9.7 million barrels per day in the week ending February 19, 2021. This was the largest weekly decline ever recorded and came with refinery crude inputs falling to their lowest level since 2008 (EIA, 2021; Reuters, 2021). This led to NYMEX WTI futures reaching $59.47 per barrel on Friday, February 12, then rising to $60.05 on Tuesday, February 16 and hitting a high at $61.14 on February 17 before settling at $61.49 on February 22 (NYMEX settlement prices via Yahoo Finance, 2021).

Winter Storm Uri is a particularly effective event for this experiment for three reasons. First, it was a direct crude supply shock since physical production was shut in at the well itself, unlike disruptions to refineries or pipelines that leave upstream production largely indifferent. The second reason is the timing of the storm since U.S. equity markets were closed on Monday, February 15 for Presidents Day while the freeze intensified. This meant the market's first full trading response was easily observable on Tuesday, February 16. Lastly, the storm led to a contrast for oil companies in which all producers benefit from higher crude prices, but producers whose own wells froze simultaneously lose sales volumes.

1.2 Petroleum Firm Classifications

Large-cap integrated petroleum firms are defined within this study as companies with market-caps exceeding $70 billion USD that operate across the full petroleum supply chain, including upstream exploration and production, midstream transportation, and downstream refining and marketing. Their global operations diversification and supply chain structure are expected to buffer the rapid change of the equity price in the event of any single regional disruption (Brealey et al., 2019). The four firms that meet this definition in the experimental sample are ExxonMobil Corporation (XOM), Chevron Corporation (CVX), Shell plc (SHEL), and TotalEnergies SE (TTE), with approximate market capitalizations as of February 12, 2021, of $215 billion, $174 billion, $147 billion, and $120 billion respectively (Yahoo Finance, 2021; SEC company filings).

Small-and mid-cap E&P (exploration and production) firms are defined within this study as companies with market capitalizations between approximately $0.3 billion and $5 billion USD whose revenues are derived predominantly from upstream crude oil production. These firm's operations often occur in specific geological basins along with relatively low downstream activity and come with higher market betas consistent with their operating and financial leverage (Mandelker & Rhee, 1984). The four firms in this group are Murphy Oil Corporation (MUR, approximately $2.0 billion), Centennial Resource Development, Inc. (CDEV, approximately $0.8 billion), Talos Energy Inc. (TALO, approximately $0.8 billion), and W&T Offshore, Inc. (WTI, approximately $0.4 billion (additionally the firm's NYSE ticker coincides with the WTI crude oil benchmark but they will be addressed separately in this paper). Murphy Oil operates in a diverse area of upstream regions from the deepwater Gulf of Mexico, the Eagle Ford Shale, and international offshore reservoirs (Murphy Oil Corporation, 2021). The other three are basin-focused firms and have mixed exposure to the storm itself. Centennial Resource Development was a pure-play Permian Basin operator whose wells sat directly in the freeze zone of the storm, giving it the sample's highest in-zone exposure. Talos Energy and W&T Offshore produce exclusively from the offshore Gulf of Mexico, where production was not shut in by the freeze. Murphy Oil has onshore Eagle Ford operations which lay within the affected region while its deepwater Gulf of Mexico operations did not, so it carried partial exposure to the zone of the winter freeze and affected area. This provides group variation in physical exposure that Section 4.3 uses to separate the price channel of the shock from the volume channel.

1.3 Research Question and Hypotheses

This study's central question is whether scale and supply chain specialization (or integration) produce measurably different equity pricing responses to a regional crude supply shock, and if so, how quickly and persistently will that difference appear. Prior findings in this area show that E&P-focused firms carry higher operational leverage and beta exposure to crude prices than vertically integrated supermajors (Mandelker & Rhee, 1984), but relatively few studies isolate this comparison using a regional disruption that physically constrains supply at the source rather than looking at the results of shifting demand expectations. Winter Storm Uri is a perfect example since the event shut in production directly at the wellhead which created a bounded supply shock that also occurred during market closing. This design tests whether the structural differences between large integrated firms and small/mid-cap E&Ps translate into observable and distinguishable equity price behavior in the short-term window around a supply disruption—and whether any such observed differences are immediate or persistent across the full timeline.

Hypothesis 1 (H1): On the first trading session following the supply shock ($\tau = 0$), small-and mid-cap E&P equities will exhibit a larger positive mean abnormal return than large-cap integrated equities, because their revenues and operations are more concentrated in upstream crude exposure and their shares carry higher operational leverage (Mandelker & Rhee, 1984; Sharpe, 1964).

Hypothesis 2 (H2): During the event window, small-and mid-cap E&P equities will show statistically higher daily return volatility than large-cap integrated equities, which are the product of greater

uncertainty about how the stock's price and volume effects net out for more specialized producers.

Null Hypothesis (H3): This hypothesis states that capitalization and supply chain integration does not matter in regards to equity pricing behavior in the aftermath of an oil supply disruption, and the shock is priced uniformly across all the companies.

METHODOLOGY

2.2 Event Selection and Event Timeline

The event date ($\tau = 0$) is Tuesday, February 16, 2021, the first NYSE trading session after Winter Storm Uri's production shut-ins became publicly known. The freeze largely intensified over the weekend of February 13–14 as electrical blackouts continued across Texas on the morning of February 15 (Federal Energy Regulatory Commission [FERC], North American Electric Reliability Corporation [NERC], & Regional Entities, 2021). Additionally, U.S. equity markets were closed on Monday, February 15 for Presidents Day as well. Session $\tau = -1$ is Friday, February 12 which is consistent with the convention of including the session immediately preceding the event to account for trading anticipation and information leakage (Brown & Warner, 1985). Sessions $\tau = +1$ through $\tau = +4$ run from Wednesday, February 17 through Monday, February 22, which span the peak of the physical disruption and the beginning of production restoration (Reuters, 2021).

Following Brown and Warner (1985) and MacKinlay (1997), firm-specific expected-return parameters are estimated over a 100-trading-day estimation window at $\tau = [-120, -21]$, which runs from August 24, 2020, through January 14, 2021. A 19-trading-day buffer ($\tau = -20$ to $\tau = -2$, corresponding to January 15 through February 11, 2021) is also used and is what separates the estimation window from the event window so that anticipatory trading does not interfere with estimates involved.

2.3 Sample Selection and Clean Sample Protocol

A Clean Sample Protocol was used during formation of the sample group. This means that any candidate firm (that meets the established market-cap guidelines for each group) with a firm-specific significant corporate event (an earnings release, reserves report, dividend policy announcement, merger or acquisition activity, or securities/debt issuance) inside the event window of February 12–22, 2021 was excluded. This is because such disclosures can interfere with equity pricing and result in the lack of the ability to isolate the direct effects of the supply shock. (MacKinlay, 1997). The event window also overlaps with the fourth-quarter 2020 earnings season for U.S. independent producers, which makes the CSP's (Clean Sample Protocol's) use more relevant.

Table 1 shows the screening outcome for every candidate firm, using data verified from SEC Form 8-K filings and company press releases. Below is a summary of what was found and the consequent result of their inclusion in the sample, along with the methodology regarding the companies rejection or acceptance:

Ticker	**Firm**	**Q4 2020 earnings date**	**Other window events**	**Decision**
XOM	ExxonMobil	Feb 2, 2021	None	Included
CVX	Chevron	Jan 29, 2021	None	Included
SHEL	Shell (then Royal Dutch Shell plc)	Feb 4, 2021	None	Included
TTE	TotalEnergies (then TOTAL SE)	Feb 9, 2021	None	Included
MUR	Murphy Oil	Jan 28, 2021	None	Included
CDEV	Centennial Resource Dev.	Feb 23, 2021 (post-window)	None	Included
TALO	Talos Energy	Mar 10, 2021	None	Included
WTI	W&T Offshore	Mar 3, 2021	None	Included
SM	SM Energy	Feb 17, 2021 ($\tau = +1$)	—	Excluded
MTDR	Matador Resources	Feb 23, 2021	Reserves release Feb 17 ($\tau = +1$); dividend policy Feb 22 ($\tau = +4$)	Excluded
MGY	Magnolia Oil & Gas	Feb 22, 2021 ($\tau = +4$)	—	Excluded
COP	ConocoPhillips	Feb 2, 2021	Market cap below $70B threshold; upstream-only, not integrated	Excluded

Table 1. Clean Sample Protocol screening. Earnings and event dates are from SEC Form 8-K filings and company press releases. Laredo Petroleum (LPI), a small-cap Permian producer, rescheduled its Q4 2020 release from February 17 to after market close on February 22, 2021 explicitly because the storm impaired its field operations (Laredo Petroleum, 2021). It was excluded because the rescheduling disclosure itself occurred at $\tau = 0$. Several otherwise ideal early 2020s mid-cap producers (Denbury, Callon Petroleum, PDC Energy, Whiting Petroleum, Oasis Petroleum, Bonanza Creek, Earthstone, etc.) could not be included because their historical price data has been removed from public data providers following post-2021 acquisitions and delistings (this constraint is further discussed in Section 5.3). CDEV's release one trading day after the window closed is retained under the protocol, which excludes only disclosures inside the window. A screen of every included firm's filings during February 12–22, 2021 show only routine administrative events such as a director-dealing notification for Shell (Form 6-K, February 17), a severance-plan approval for Centennial (Form 8-K Item 5.02(e), February 17), insider compensation

reports (Forms 4) for Murphy Oil, and a third-party passive-ownership amendment (Schedule 13G/A) referencing TotalEnergies. None of these constitute as a material corporate disclosure under the established protocol.

The final sample ultimately consists of four large-cap oil super majors and four small-and mid-cap E&P firms. It is also noted that TOTAL SE was renamed TotalEnergies SE, with the NYSE ticker changing to TTE, in June 2021, and that Royal Dutch Shell was renamed to Shell, with its NYSE listing under the ticker SHEL, in January 2022. The current names and tickers are used in this paper for clarity with the current state of the NYSE. The SPDR S&P 500 ETF Trust (SPY) serves as the market comparison for all return models in this study. Lastly, two of the integrated large-cap firms (XOM and CVX) were part of the S&P 500 with a combined index weight of roughly 1.2% during the study period (SHEL and TTE are not index members), which is acknowledged as a limitation in Section 5.3.

2.4 Framework and Statistical Methodology

All returns are continuous (logarithmic) daily returns calculated from dividend-and split-adjusted closing prices obtained from Yahoo Finance:

$$R_{i,t} = \ln(P_{i,t} / P_{i,t-1})$$

Expected returns follow the single-factor market model (Sharpe, 1964; Fama, 1976), in which each firm's return is a linear function of the market return:

$$R_{i,t} = \alpha_i + \beta_i R^m_t + \varepsilon_{i,t}$$

Firm-specific alpha and beta are estimated by ordinary least squares over the 100-day estimation window:

$$AR_{i,t} = R_{i,t} - (\hat{\alpha_i} + \hat{\beta_i} R^m_t)$$

Cumulative abnormal returns are the sums of daily abnormal returns across the event window (MacKinlay, 1997; Campbell, Lo, & MacKinlay, 1997):

$$CAR_i(\tau_1, \tau_2) = \Sigma\, AR_{i,\tau}, \quad \tau = \tau_1, \ldots, \tau_2$$

Cross-group differences in mean abnormal returns are tested at each event session with Welch's two-sample unequal-variances t-test (Welch, 1947), with degrees of freedom that are calculated from the Welch–Satterthwaite approximation. The Welch calculation was selected because it does not assume equal population variances across the two groups, which is important in regards to the different corporate structures and beta differences between the large vs mid-cap firms. Due to the n=4 firms per group, degrees of freedom range from 3.4 to 5.8 across trading sessions, and the corresponding two-tailed critical values at the 95% confidence level range from 2.47 to 2.98. The small sample size limits statistical power, and this constraint is acknowledged in Section 5.3.

The volatility hypothesis (H2) is tested with the median-focused Brown–Forsythe variant of Levene's test for calculating the overall equality of variances (Brown & Forsythe, 1974; Levene, 1960). This is applied

to the pooled event-window daily returns of each group (four firm times six sessions, or 24 total return observations per group). The median-focused calculation was selected over the original mean-focused method because it is the most consistent in regards to separation from what is normal or standard

RESULTS

3.1 Baseline Estimation Parameters

Table 2 reports the OLS parameters for each firm over the estimation window of August 24, 2020 through January 14, 2021. Every estimated beta is statistically significant, with t-statistics ranging from 3.6 to 5.6. The mean baseline beta of the small/mid-cap group ($\bar{\beta} = 1.93$) is 82.9% higher than that of the large cap group ($\bar{\beta} = 1.05$), which confirms that small/mid-cap E&Ps carry higher sensitivity to broader crude pricing changes under baseline conditions There are two important features in regards to Table 2. The coefficients of determination are low ($R^2 = 0.118$ to 0.243), which is typical for single-stock market models at a daily frequency but it means the expected-return baseline is estimated with large amounts of variance—meaning abnormal returns should be read accordingly. Additionally, the estimated alphas are somewhat large, most noticeable in regards to Centennial ($\hat{\alpha} = 0.00989$ per day, which compounds to roughly +169% over the 100-day window). This is likely the product of Centennial's post-COVID equity spike, during which its share price rose approximately 240% within the estimation window. Because the model subtracts $\hat{\alpha}_i$ from each realized return, a large positive alpha reduces that firm's measured abnormal returns during the event window. This is ultimately more conservative with respect to H1. As previously mentioned, the estimation window includes the November 2020 vaccine-announcement. A later event-study written after 2021 shows that energy was among the sectors that benefited most from the November 9, 2020 announcement (Kapar, Buigut, & Rana, 2022). This specifically was a period of extreme sector-wide change that elevated baseline volatility for all firms in this sample.

Cohort	Ticker	Mkt Cap (Feb 2021)	Alpha ($\hat{\alpha}$)	Beta ($\hat{\beta}$)	SE($\hat{\beta}$)	t($\hat{\beta}$)	R^2
Integrated	XOM	$215B	0.00114	0.977	0.226	4.32	0.160
Integrated	CVX	$174B	0.00003	1.084	0.194	5.60	0.243
Integrated	SHEL	$147B	0.00232	1.021	0.234	4.37	0.163
Integrated	TTE	$120B	0.00090	1.132	0.210	5.40	0.230
Small/Mid	MUR	$2.0B	−0.00135	2.122	0.435	4.88	0.195
Small/Mid	CDEV	$0.8B	0.00989	2.003	0.552	3.63	0.118
Small/Mid	TALO	$0.8B	0.00162	1.767	0.480	3.68	0.121
Small/Mid	WTI	$0.4B	−0.00107	1.815	0.444	4.09	0.146

Table 2. OLS single-factor market-model parameters estimated over the 100-trading-day window ending January 14, 2021, using daily log returns and the SPY market proxy. Group means: integrated $\bar{\alpha} =$

0.00110, $\bar{\beta}$ = 1.054; small/mid $\bar{\alpha}$ = 0.00227, $\bar{\beta}$ = 1.927 (β differential +82.9%). All betas are significant at $p < .01$. Market capitalizations are approximate values as of February 12, 2021, computed from unadjusted closing prices and shares outstanding reported in company filings.

3.2 Event-Window Abnormal Returns

Table 3 shows the group mean abnormal returns, the cross-group differential (δ), Welch test statistics with Welch–Satterthwaite degrees of freedom, and the cumulative abnormal return paths for each event session. Table 4 reports the underlying individual-firm abnormal returns so that in-group differences can be further inspected.

τ	Date	R^m	Integrated AR	Sm/Mid AR	δ	Welch t	W–S df	p
−1	Fri, Feb 12	+0.49%	+1.01%	+2.91%	+1.90%	1.32	3.8	.262
0	Tue, Feb 16	−0.09%	+3.06%	+4.67%	+1.60%	3.12	5.8	.021*
+1	Wed, Feb 17	+0.02%	+1.75%	+0.07%	−1.68%	−0.97	3.4	.395
+2	Thu, Feb 18	−0.43%	−1.58%	−3.81%	−2.23%	−2.41	4.8	.063
+3	Fri, Feb 19	−0.18%	+1.27%	+2.70%	+1.43%	1.53	3.8	.206
+4	Mon, Feb 22	−0.77%	+3.14%	+5.32%	+2.18%	2.23	4.7	.080

Table 3. Group mean daily abnormal returns (continuous log returns, in percent). * $p < .05$, two-tailed Welch's unequal-variances t-test with Welch–Satterthwaite degrees of freedom. δ = small/mid-cap mean AR − integrated mean AR. Cumulative abnormal return paths: integrated +1.01 → +4.07 → +5.82 → +4.24 → +5.51 → +8.65 percent; small/mid +2.91 → +7.57 → +7.64 → +3.83 → +6.53 → +11.85 percent. NYMEX WTI settlement prices across the same sessions: $59.47, $60.05, $61.14, $60.52, $59.24, and $61.49 per barrel. This model specifically subtracts each firm's beta-adjusted market return before ARs are calculated, so broad market movements during the window are already accounted for. Group means, differentials, and CAR paths are calculated from unrounded firm-level values; displayed components may not sum exactly due to rounding.

τ	XOM	CVX	SHEL	TTE	MUR	CDEV	TALO	WTI
−1	+0.76	+0.04	+2.40	+0.84	+2.84	+6.74	+0.73	+1.32
0	+2.93	+2.12	+4.03	+3.18	+4.30	+3.95	+5.41	+5.00
+1	+1.41	+2.92	+0.76	+1.90	+2.61	−4.38	+2.65	−0.60

+2	−1.28	−0.50	−2.69	−1.85	−4.63	−2.12	−5.63	−2.87
+3	+0.73	+1.03	+1.14	+2.18	+4.26	+4.16	+0.90	+1.48
+4	+4.26	+3.50	+2.73	+2.07	+6.74	+3.82	+6.88	+3.86

Table 4. Individual-firm daily abnormal returns (percent). The divergence within the small/mid group at τ = +1 and τ = +2 (most notably CDEV at −4.38% (τ = +1) and TALO at −5.63%, τ = +2) reflects the varying degrees of physical exposure to the storm discussed in Section 4.3.

At τ = 0 the small/mid-cap groups mean abnormal return of +4.67% was greater than the large-caps +3.06% by 1.60%, and this difference is also statistically significant (t = 3.12, Welch–Satterthwaite df = 5.8, p = .021). This is the only event session at which the cross-group difference clears the 95% confidence framework that was established earlier in this experiment. Additionally, the difference reverses in at τ = +2 (δ = −2.23 percentage points, t = −2.41, p = .063, marginally significant) which does coincide with the peak of the physical disruption that resulted in producers losing sales volumes even as prices rose. Lastly, cumulative abnormal returns over the six-session window were higher in the small/mid-cap group (+11.85% versus +8.65%, a differential of 320 basis points), but a Welch test applied to the firm-level full-window CARs did not reject equality (t = 1.93, p = .146). The entire sector earned large positive abnormal returns during the week which is consistent with the WTI price change and overall analyst sentiment that the supply disruption was bullish for crude prices.

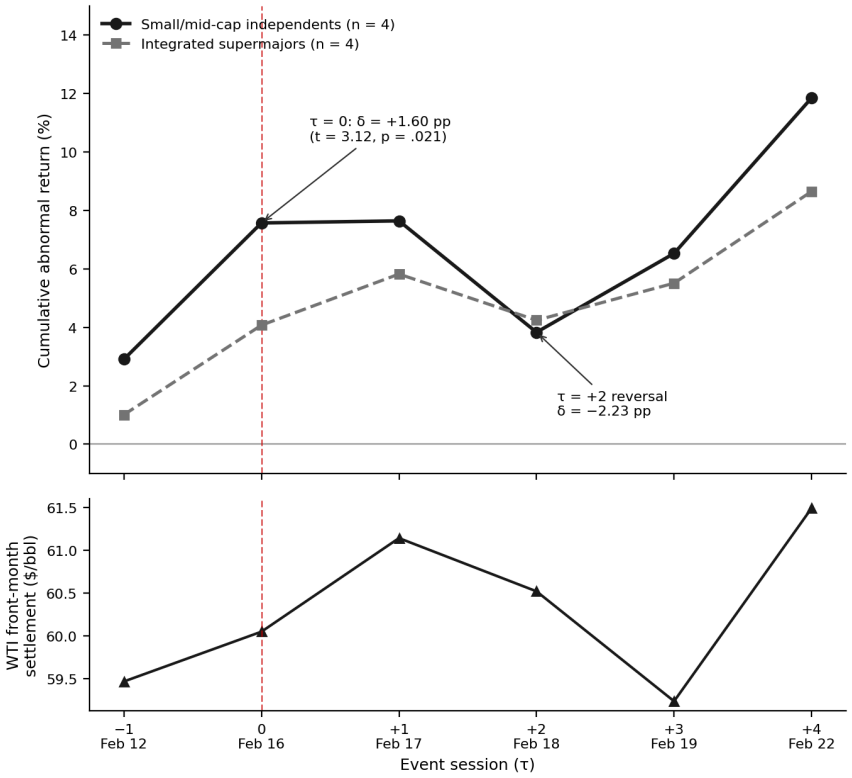


Figure 1. Cumulative abnormal return paths by group (upper panel) and front-month NYMEX WTI settlement

prices (lower panel) across the event window. The dashed vertical line marks the event date (τ = 0, February 16, 2021). The small/mid-cap group starts at a statistically significant gap at τ = 0, which closes at τ = +2 as the volume-offset effect discussed in Section 4.3 occurs. Ultimately both groups recover at τ = +4. CAR paths are calculated from unrounded firm-level abnormal returns.

On volatility, mean daily return standard deviations during the event window were 3.94% for the small/mid-cap group versus 1.90% for the large-cap group, which is a ratio of 2.07 to 1. The Brown–Forsythe test applied to the pooled event-window daily returns rejects equality of variances ($W = 6.71$, $p = .013$). This ultimately supports H2 in which the conclusion is not sensitive to the centering choice, as the original mean-centered Levene statistic rejects equality as well ($W = 9.14$, $p = .004$). It also should be noted that the event-window volatility for both groups was lower than estimation-window volatility (large 2.66%, small/mid 5.70%), because the estimation window contains the November 2020 vaccine-announcement. H2 is therefore framed and tested more-so as a cross-group comparison during the event window.

3.3 Event-Date Result

Because the group sample size is relatively small (n=4 per group) and the estimated alphas are large (Section 3.1), the significant τ = 0 difference means that there had to be a deeper analysis into the differential itself. This led to five additional checks to make sure the statistical difference was valid.

A nonparametric bootstrap of the τ = 0 differential (10,000 resamples with replacement from each group, random seed fixed for reproducibility) produced a 95% confidence interval of [+0.76%, +2.46%], which excludes zero. 100% of resampled differentials were positive. Additionally, a leave-one-out check re-estimated the τ = 0 differential eight times in which one firm from one group was dropped. The differential remained positive and similar in every case, ranging from +1.29% (dropping CVX) to +1.92% (dropping SHEL), which establishes that no single firm drives the results in each group. Third, the Mann–Whitney U yielded a $U = 15.0$ and $p = .057$, which fell barely short of the 95% threshold. Also, the possibility that the differential simply reflects a small-firm (SMB) risk premium that could have been realized during a volatile week is addressed as well. A static size premium would produce a consistent differential across the event window, but there is a sharp rise at τ = 0 (+1.60%) followed by a reversal at τ = +1 and τ = +2, with the mean differential across the other five sessions being only +0.32%. The rapid up-and-down changes are inconsistent with a static size-factor methodology and are consistent with event-driven price change. Taken together, these five checks should be read with a distinction between statistical significance and magnitude. The τ = 0 differential of +1.60% is statistically significant ($p = .021$) and holds across specification, but it is a single-session result that reverses immediately the following session and does not accumulate into a statistically significant six-session CAR differential ($p = .146$). The positive six-session CAR differential of 3.2% is economically meaningful but statistically indistinguishable from zero given the small sample size. The overall pattern of evidence supports an immediate repricing difference at the event date rather than a sustained difference across the full window which is a distinction that should be kept in mind when interpreting the results of the individual robustness tests.

Lastly, the entire analysis was re-estimated under the market-adjusted-returns model, in which the

intercept is constrained to zero ($AR_{i,t} = R_{i,t} - \beta_i R^m_t$). Brown and Warner (1985) treat this as an alternative to the market model, and it is the natural check on the issue raised in Section 3.1 that the estimated alphas (mostly Centennial's) are unrealistically large. The $\tau = 0$ differential rises from +1.60 to +1.72 percentage points ($t = 3.28$, $p = .021$) and the full-window cumulative differential rises from 320 to 391 basis points. The estimated-alpha specification does produce the more conservative estimates and it is retained as the main specification and the market-adjusted results are also reported here as well.

Check	**Statistic**	**Result**	**Interpretation**
Bootstrap (10,000 resamples)	95% CI on $\delta(\tau = 0)$	[+0.76%, +2.46%]	Excludes zero; 100% of draws positive
Leave-one-out (8 iterations)	Range of $\delta(\tau = 0)$	+1.29% to +1.92%	No single firm drives the result
Mann–Whitney U (nonparametric)	U = 15.0	p = .057	Corroborates direction; marginal at 95%
SMB confound check	$\delta(\tau = 0)$ vs. mean δ(other sessions)	+1.60% vs. +0.32%	Spike-and-reverse inconsistent with static size premium
Market-adjusted model ($\alpha \equiv 0$)	$\delta(\tau = 0)$; full-window CAR δ	+1.72% ($p = .021$); +391 bps	Removing alphas strengthens results; primary spec is conservative

Table 5. Robustness checks on the event-date ($\tau = 0$) cross-group differential. The bootstrap uses resampling with replacement within each cohort and a fixed random seed; the leave-one-out analysis drops each of the eight sample firms in turn. All four checks are reproduced by the companion analysis script.

DISCUSSION

4.1 Hypothesis 1: Immediate Differential Repricing

The results support H1 at the event date. In the first trading session after the freeze, both groups' equity prices went sharply upward, and the upstream mid/small-cap firms were repriced much more drastically than the large integrated firms.The direction of the price and the timing are consistent with the idea that a crude supply disruption raise near-term crude prices, and firms whose revenue are more tied into upstream production capture more of that pricing benefit effect per dollar of market value than larger firms, whose refining operations simultaneously face higher costs that compress their margins (Brealey et al., 2019). The magnitude of this difference is statistically significant since a 1.60% single-session differential is more than four-fifths of the large-cap group's entire average daily standard deviation during

the event window. But, by $\tau = +1$ the difference had reversed and the cumulative differential over the six sessions, while positive at 320 basis points, is not statistically distinguishable from zero at conventional confidence levels given the sample size. The data supports an immediate price change difference rather than a persistent and continuous one. It should be noted, however, that this single-event study with $n = 4$ firms per group establishes that the two groups responded differently during this specific event; it does not establish that the supply shock itself caused the observed differential in a generalizable sense. Potential issues—including a size-factor premium and within-group variation in physical disruption-zone exposure (discussed in Sections 3.3 and 4.3)—cannot be fully ruled out, and the design does not support causal inference beyond the observed association for this event.

4.2 Hypothesis 2: Event-Window Volatility

The results support H2 as well. Small/mid-cap daily returns were more than twice as volatile as large-cap returns during the event window, and the Brown–Forsythe test rejects equality of variances at $p = .013$. This is consistent with the higher betas estimated in the baseline window. Both groups were less volatile during the event week than during the estimation window, because the estimation window includes November 2020, when vaccine announcements resulted in a rapid one-day energy-sector repricing (Kapar et al., 2022). The volatility hypothesis is evaluated purely as a comparison between groups within the event window.

4.3 The Reversal at $\tau = +2$ and the Volume-Offset Channel

The most noticeable result of this study is the reversal of the cross-group differential at $\tau = +2$. Winter Storm Uri did raise crude prices but producers physically closest to the disruption lost production. The FERC-NERC investigation showed that widespread wellhead and gathering-system freeze-offs across the affected producing regions occurred during the event (FERC et al., 2021). Centennial Resource Development, a Permian Basin operator whose wells sat directly in the freeze zone, had the largest negative abnormal return at $\tau = +1$ (−4.38%), exactly when WTI peaked at $61 per barrel. Laredo Petroleum, a somewhat comparable Permian E&P that was eliminated out of the sample under the Clean Sample Protocol, disclosed on February 16 that the storm had so greatly impaired its field to the point of forcing it to reschedule its earnings release (Laredo Petroleum, 2021). This demonstrates that the operational damage to in-zone producers was publicly known during the window. The offshore Gulf of Mexico producers Talos and W&T's volumes were unaffected by the onshore freeze, which led to the capturing of the price benefit without a volume loss through $\tau = +1$. Murphy Oil, with only partial in-zone exposure in Eagle Ford, fell between the two extremes, before the energy sector pulled back at $\tau = +2$ as WTI fell from its high (EIA, 2021).

The primary implication is that a regional supply shock is not consistently bullish even for purely upstream companies. For producers inside the disruption zone, the volume and production channels work against the benefits of the rising pricing of crude. Treating regional supply shocks as pure oil price events that are expected to benefit all oil companies is a somewhat two-dimensional assumption.

CONCLUSION

5.1 Summary of Findings

This study found that Winter Storm Uri produced a statistically significant single-session abnormal-return differential of +1.60 percentage points in favor of small- and mid-cap petroleum firms over the supermajors ($t = 3.12$, $p = .021$; bootstrap 95% CI [+0.76%, +2.46%]). It also showed significantly higher small/mid-cap return volatility during the event window (a 2.07-to-1 ratio, Brown–Forsythe $p = .013$); and a positive but statistically insignificant cumulative differential over the full six-session window (+320 basis points, $p = .146$). Baseline betas for the small/mid-cap group were 82.9% higher than the large cap group, and all market-model parameters were estimated from a 100-trading-day window with statistically significant fits. The reversal at $\tau = +2$, traced in the individual-firm data to producers whose own volumes were shut in, demonstrates that regional supply shocks affect specialized producers through changes in production volume.

5.2 Implications for Investors and Portfolio Managers

The results ultimately show that the petroleum sector cannot be treated as a group of similar equities during regional supply shocks. Small-and mid-cap E&Ps deliver a larger and immediate repricing when a crude supply shock occurs but at the disadvantage of double the daily volatility; which also depends on whether the specific producer's operations sit inside or outside the disruption zone. Portfolio managers (PM's) who want to capture the benefits of exposure to regional supply shocks should differentiate energy equities not only by market capitalization and supply chain operations, but also by the geographic overlap between each producer's operations and where the disruption actually is (Brealey et al., 2019).

5.3 Limitations and Future Research

The group sample size of $n = 4$ per group is small. Welch–Satterthwaite degrees of freedom ranged from roughly 3.4 to 5.8 which means statistical power is limited, and individual firms can move total group means by a large amount, which is why the individual-firm abnormal returns are published in full in Table 4. Additionally, the actual sample construction was limited by two events. Firstly, the window overlaps the fourth-quarter 2020 earnings season, which disqualified several ideal mid/small-cap firms under the Clean Sample Protocol, and post-2021 industry consolidation has removed the historical price data of many early 2020s mid-cap producers from public data providers. Also, the estimation window includes the November 2020 vaccine rotation, which elevated baseline volatility and beta estimates which meant the analysis was framed to avoid any baseline-versus-event volatility comparison. Additionally, the SPY contains two of the super major study firms (XOM and CVX) at a combined index weight of around 1.2. This is a single-event study, and generalization to other regional supply shocks requires replication across different events.Additionally, the experimental design compares different levels of market-caps which means part of the measured differential could in principle reflect a size-factor realization during the event week rather than the supply shock itself. Further extensions of this experiment include documenting the results of other regional supply shock events (hurricanes, geopolitical conflict, etc.) that directly inhibit crude extraction.

DATA AVAILABILITY

Price data was retrieved from Yahoo Finance. Centennial Resource Development's price history was retrieved under its successor listing (Permian Resources Corporation, NYSE: PR), which preserves the continuous adjusted share-price history of the original CDEV listing.

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