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Oil Price Movements and Risks of Energy Investments

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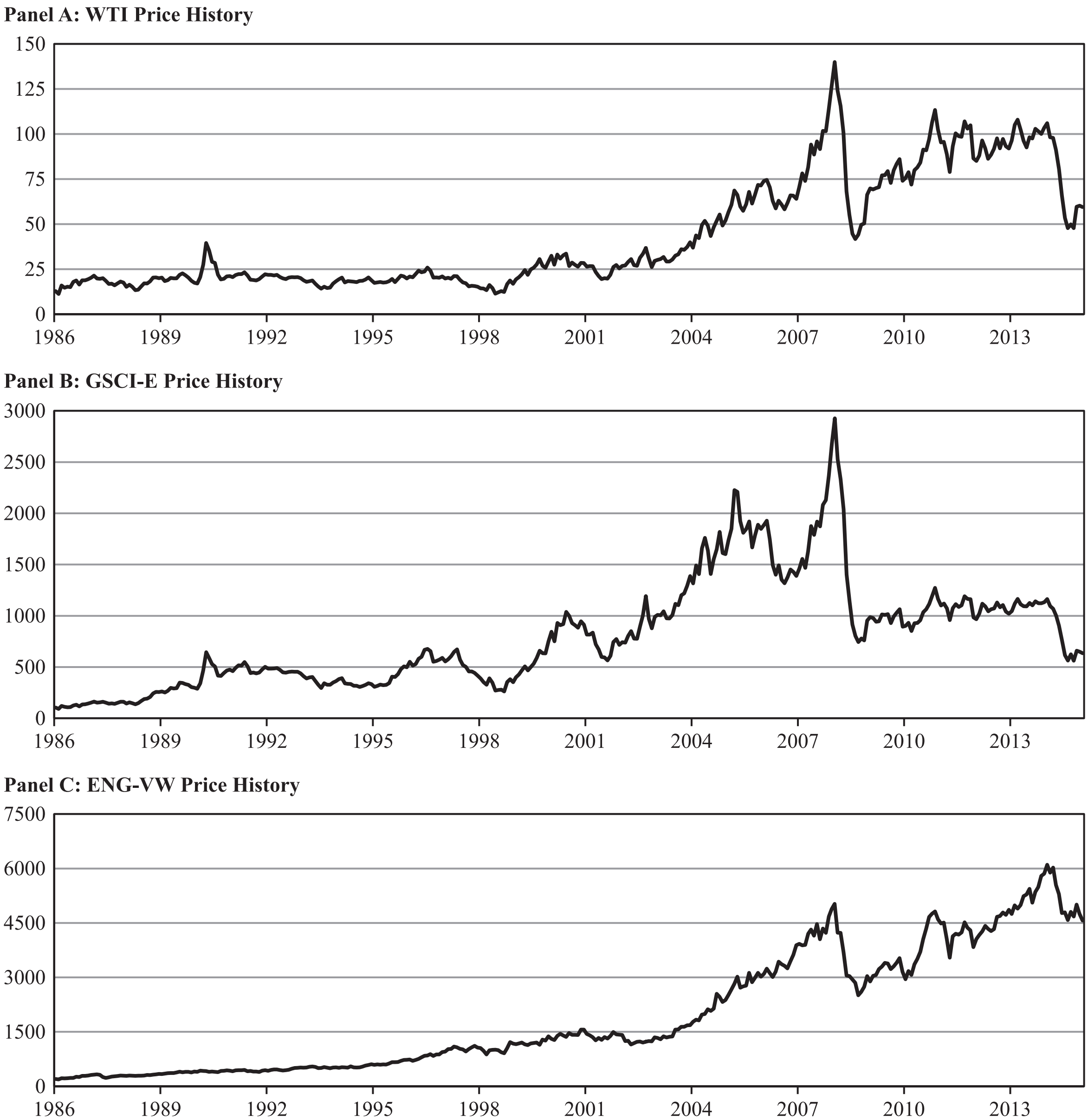
Since Gorton and Rouwenhorst [2006], commodities have been viewed as an increasingly important component of institutional investment portfolios. Through an extensive study of commodity returns from 1959 through 2004, these authors find that commodities as an asset class offer the same return and Sharpe ratio as equities. Yet commodities behave quite differently than stocks and bonds over the business cycle. The low correlation of commodities with major asset classes generates a potentially substantial diversification benefit. Other research finds that commodities serve as an important hedge against inflation risk. Combined, these results have helped solidify the commodity and real assets space as a separate asset class in most large institutional portfolios.

The correlation findings of Gorton and Rouwenhorst [2006] are fairly robust, having been corroborated in the academic literature by studies using different data sources, time periods, and statistical techniques.[1] In addition to the academic work, investors increasingly acknowledge the potential benefits of diversifying into real assets more broadly. For example, research by StepStone Global LP [2014] suggests that investments in real assets have grown increasingly common over time: from 10% of total private market commitments in 2000 to more than 30% in 2013. Moreover, the median fund size for energy-focused private equity funds has grown substantially from about $200 million in 2000 to approximately $350 million in 2010.

Nonetheless, since the Great Recession of 2008–2009, investors with direct exposure to energy commodities have experienced tremendous volatility and low returns. For example, as seen in Panel A of Exhibit 1, the price of West Texas Intermediate (WTI) crude oil fell from roughly $140 a barrel in June 2008 to about $41 a barrel in January 2009. In addition, oil prices have fallen roughly 50% during the 12 months between June 30, 2014, and June 30, 2015. These recent price swings have been connected to supply–demand imbalances. Slowing global economic growth, particularly in China, has lowered energy demand.[2] Meanwhile, the U.S. Energy Information Administration reports that from 2008 to 2014, U.S. crude oil output increased by a total of 70%. Combined with steady, high levels of output from OPEC nations, U.S. crude inventories increased by more than 40% between February 2003 and November 2015, according to data from the U.S. Energy Information Administration (EIA).[3] However, more recently, the EIA reports that U.S. energy production has leveled off since the fall of 2014.[4] Since the Great Recession, broader energy prices as measured by the energy component of the Goldman

Exhibit 1
Energy Prices



Notes: Panel A plots monthly spot prices of West Texas Intermediate (WTI) crude oil (USD/bbl). Data provided by NYMEX. Panel B plots the level of the Goldman Sachs Commodity Index, energy sector (GSCI-E). Each series is plotted using the closing value for the last day of the month for the period June 1986 to June 2015. Panel C plots the monthly value-weighted index of public U.S. stocks in the energy sector (ENG-VW) obtained from Ken French's website for the period June 1986 to June 2015.

Sachs Commodity Index (GSCI-E) experienced even lower returns than did WTI (see Panel B of Exhibit 1). However, returns of energy-focused equities over the same period recovered to reach new highs in 2014 (see Panel C of Exhibit 1). These different trends demonstrate that investors wanting energy exposure can have very different experiences depending on the specific types of investments they make.

Despite the low correlation between energy prices and broad equity indexes, there exists a positive relationship between oil price movements and the returns on energy-focused public equity.[5] As a case in point, the S&P energy-sector index lost about 25% of its value during the June 30, 2014, through June 30, 2015, period when WTI crude oil prices declined by about 44%. However, it is not as well understood how energy-focused private equity investments react to energy price movements, although similar correlations are likely to exist. For example, using our proprietary data (discussed in the following), we find the pooled internal rate of return (IRR) for energy-focused private equity funds during the same time period was −12.3%, although this estimate is subject to the usual caveats concerning private fund returns.[6] The primary objective of this article is to better understand the relationship between energy prices and returns to energy-focused private equity investments. More broadly, we seek a better understanding of the risk and return history of various investment strategies in the energy space.

Our analysis in the remainder of this article uses several proxies of energy exposure. We capture broad price movements of energy-based commodities via the GSCI-Energy index, and oil prices specifically through WTI prices. We also capture the movements of equity prices via energy-focused public equity, which we will refer to simply as public equity, as well as energy-focused private equity, which we will refer to simply as energy PE.

We find that during our sample period, energy PE funds experienced returns that are significantly higher than those of energy-based commodities as well as public equity. We also examine simple unconditional correlations as a measure of the risk at the portfolio level. We find that returns on oil prices and public equity typically exhibit large, positive correlations with each other. In contrast, energy PE is less tightly related to oil prices and public equity returns, thereby possibly offering additional diversification benefits.

We further explore these connections through a series of regressions and find that movements in oil prices drive the movements of both public equity and energy PE returns, but broader energy prices are less able to explain equity returns. WTI returns also appear to have a nonlinear (convex) relationship with three-year equity returns, and this effect is somewhat stronger for energy PE than for public equity. These results suggest that an additional benefit to investing in equities over hard commodities is the ability to capture upside exposure while limiting downside exposure and that energy-focused PE funds are potentially well suited for this purpose.

ACCESSING THE EXPOSURE DIFFERENCES

There are many ways to access investment opportunities available within the energy sector, ranging from trading commodities (e.g., trading financial derivatives on energy products) to investing in public equity, or in energy-focused PE funds. Investing in each of these alternatives involves entering into different types of financial contracts, which in turn is likely to imply different risk–return profiles. Likewise, energy investments will vary in their effectiveness as inflation hedges. For example, the set of risks characteristic of investing energy PE funds are likely to be different from that of investing with crude oil futures contracts. We hypothesize that energy PE investments generally encompass more strategy-specific risks, and are therefore typically less correlated with commodity market movements than similar investments made via publicly equity. Of course, a major confounding factor is that a lower correlation of energy PE funds could simply exist because of the difficulty in observing market values for PE investments. In our analysis, we develop a method to mitigate the potential bias in estimated correlations caused by illiquidity.

It is also important to understand that the preferred investment vehicle may vary across investors depending on the goals of, and constraints facing, a particular program. For example, investors seeking strong correlation with energy prices for short-term speculative purposes or high levels of liquidity may prefer public equity investments and outright energy commodity exposure, whereas investors seeking higher returns and equity market diversification may prefer energy PE investments. Of course, many highly diversified investors will have a place for both public and private strategies as well as possible direct commodity positions.

There is very little existing research that describes the relationship between energy PE investments and oil price movements. Research in this area has been thwarted by a lack of readily available, high-quality data as well as by the fact that institutional-quality private equity energy funds have become common only recently. In this analysis, we attempt to overcome this limitation through a collaborative effort among private-sector proprietary data sources and more traditional data sources covering public markets.[7] Our hope is that the findings of this article will enable investors to gain a better understanding of the risk–return profile of their investments in the energy sector.

DATA

In this section, we describe the three types of data used in our analysis: energy commodity prices, public equity, and energy PE. As noted previously, we utilize two data series as proxies for energy prices. First, we use the Goldman Sachs Commodity Index, energy subindex (GSCI-E) to capture movements in energy prices very broadly.[8] Second, we use the market price of West Texas Intermediate crude oil as reported by the New York Mercantile Exchange to capture movements specific to oil prices. Each series is a spot price, gathered at a monthly frequency, using the last day of the month as the recorded price. In Exhibit 1, Panel A and Panel B, we illustrate the evolution of these prices from June 1986 through June 2015. Both commodities remain in a trading range for much of the late 1980s through late 1990s. The early 2000s experienced significant price appreciation, culminating in a crash during the 2008–2009 Great Recession, and subsequent recovery in 2009–2011. Beginning in mid-2014, prices experienced another crash.

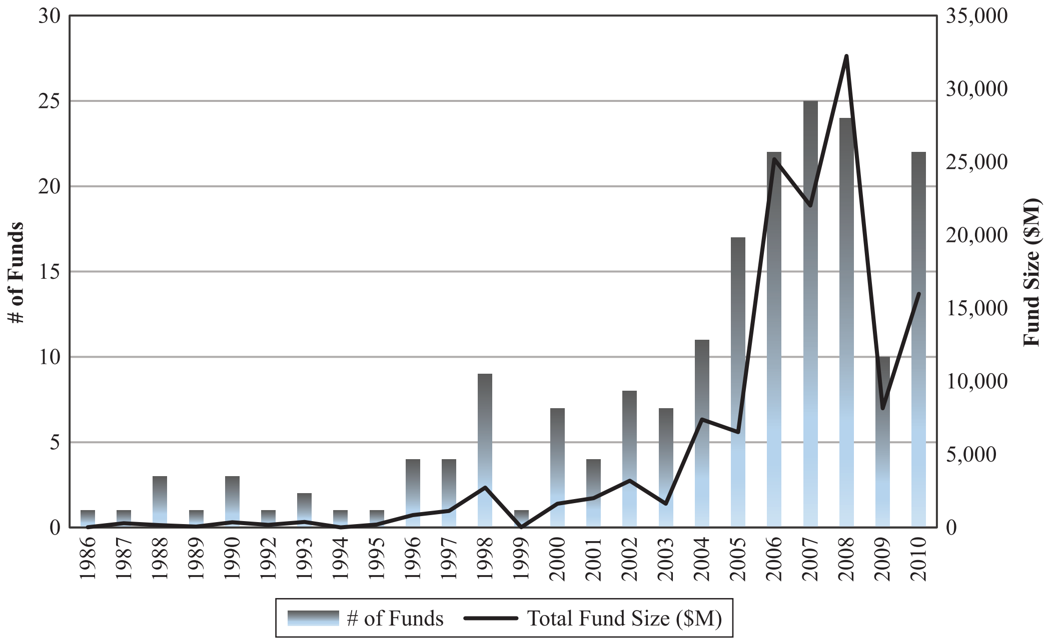
As a proxy for energy-focused public equity, we utilize the monthly value-weighted index of public U.S. stocks in the energy sector (ENG-VW). Specifically, we use the index constructed by Ken French (and available on his website), which is constructed as one of 10 industry portfolios that span all NYSE-, AMEX-, and NASDAQ-listed stocks. In Panel C of Exhibit 1 we plot this index from June 1985 through June 2015. Similar to the direct energy-based commodity investments seen in Panel A and Panel B of Exhibit 1, ENG-VW has limited movements during the late 1980s through the late 1990s. ENG-VW also exhibits a rapid ascent throughout the early- and mid-2000s, with a peak in June 2008 during the 2008–2009 Great Recession. Unlike WTI and GSCI-E, however, ENG-VW recovered and exceeded its previous high in 2013. Only recently has the index experienced a significant decline.

Finally, as a proxy for energy PE returns, we utilize two series that differ by source (Burgiss and Adams Street Partners) and construction (fund level versus company-specific level). At the fund level, we use data provided by Burgiss for 189 energy PE funds from the vintage years 1986 to 2010. Funds incepted after 2010 have been excluded because typically only a small portion of their asset value has been realized by investors. Exhibit 2 shows the number of funds and value of total commitments by vintage year in the Burgiss dataset. Of course, the number and size of funds tend to be highly, positively correlated. Each was relatively stable from the mid-1980s through the mid-1990s. With a slight interruption around 1999, the number and size of funds grew rapidly from the mid-1990s through the mid-2000s. The Great Recession pulled each lower in the late 2000s, with some evidence of a rebound in 2010, which is the last vintage year we consider in our sample.

In Exhibit 3, we present returns calculated through the second quarter of 2015 for fund-level data using four metrics. The first is the ratio of total value to paid-in capital (TVPI), where paid-in capital is the amount of committed capital that has been invested by the limited partner (LP) with the general partner (GP) and total value captures returns that are both realized and unrealized. The second metric is the internal rate of return, which is the rate at which the net present value of all cash flows from an investment is equal to zero. Our third metric is the Kaplan and Schoar [2005] Public Market Equivalent index (K&S PME), which discounts cash flows in a cash multiple computation by the returns to a public index since the fund's inception. For subperiods, we also report the direct alphas, which provide a measure of an annualized excess return (see Gredil, Griffiths, and Stucke [2014]).

Panel A of Exhibit 3 shows that energy PE funds outperform public equity with a mean K&S PME value of 1.17. This overall excess return of about 17% relative to the benchmark is similar to buyout performance but less than venture capital performance over the same period (as documented by Harris, Jenkinson, and Kaplan [2014, 2015]). However, it is important to note that there exists substantial variation in returns across subperiods. Funds raised in 1994 to 2005 show the best returns when compared with other subperiods on both an absolute and a market-adjusted basis. For example, the mean direct alphas are 5.3% in 1994–1999 and 7.2% in 2000–2005, compared with −2.7% in 1986–1993 and 0.6% in 2006–2010. When we subsequently examine the portfolio company data, we also observe significantly higher returns from energy PE investments than from the public equity. It is also important to understand that the cross-sectional dispersion of returns is large for energy PE funds. The return multiples of energy

EXHIBIT 2
Number and Size of Funds



Notes: This exhibit depicts the number of PE energy funds and their total fund size by vintage year. The data consist of 189 energy-focused private equity funds from the Burgiss database with vintage years ranging from 1986 to 2010. Fund size is defined as the level of committed capital in millions of USD.

EXHIBIT 3
PE Energy Fund Returns

Panel A: Summary of PE Energy Fund Return Metrics

	TVPI	IRR	K&S PME
Mean	1.79	11.73%	1.17
Std. Dev.	1.47	21.9%	0.61

Panel B: Return Metrics by Vintage Year Range

		TVPI		IRR		K&S PME*		Direct Alpha*	
Vintage	# of Funds	Mean	Median	Mean	Median	Mean	Median	Mean	Median
1986–1993	12	1.77	1.44	11.2%	10.3%	0.96	0.92	–2.7%	–2.7%
1994–1999	20	3.41	2.33	17.4%	18.9%	1.51	1.52	5.3%	7.9%
2000–2005	54	2.26	1.81	21.8%	17.1%	1.32	1.16	7.2%	3.8%
2006–2010	103	1.23	1.15	5.1%	4.9%	1.05	1.03	0.6%	1.0%

Notes: This exhibit describes the returns of PE energy fund data for the vintage years 1986 through 2010 provided by Burgiss. Data are measured through 2015 Q2. The return metrics used are total value to paid-in capital (TVPI), internal rate of return (IRR), and the Kaplan and Schoar Public Market Equivalent index (K&S PME). Panel A presents the mean and standard deviation for each return metric over the entire sample. Panel B presents the mean and median of returns by vintage year.

**K&S PME and Direct Alpha are calculated against the returns of a public market energy sector index.*

investments average 1.79 with a standard deviation of 1.47. Likewise, the variation in PMEs shows that while the average fund did better than public market energy companies, many did not.

In addition to the fund-level data, we utilize company-level data provided by Adams Street Partners. Exhibit 4 illustrates the disposition of these companies by sector, as well as by percentage of GP dollar investments. In total, the dataset consists of 620 realized or substantially realized[9] deals invested by more than 90 buyout funds. Exploration and Production (E&P) is the largest among the five sectors considered, both in terms of number of companies and percentage of total GP costs. Specifically, 348 E&P companies account for 56% of the total number of companies in the dataset and 38% of total investments. Meanwhile, companies in the Power/Downstream and Energy Services sectors represent 19% and 25%, respectively, of total investments. We plot the number of portfolio company investments by original investment year in Exhibit 5.

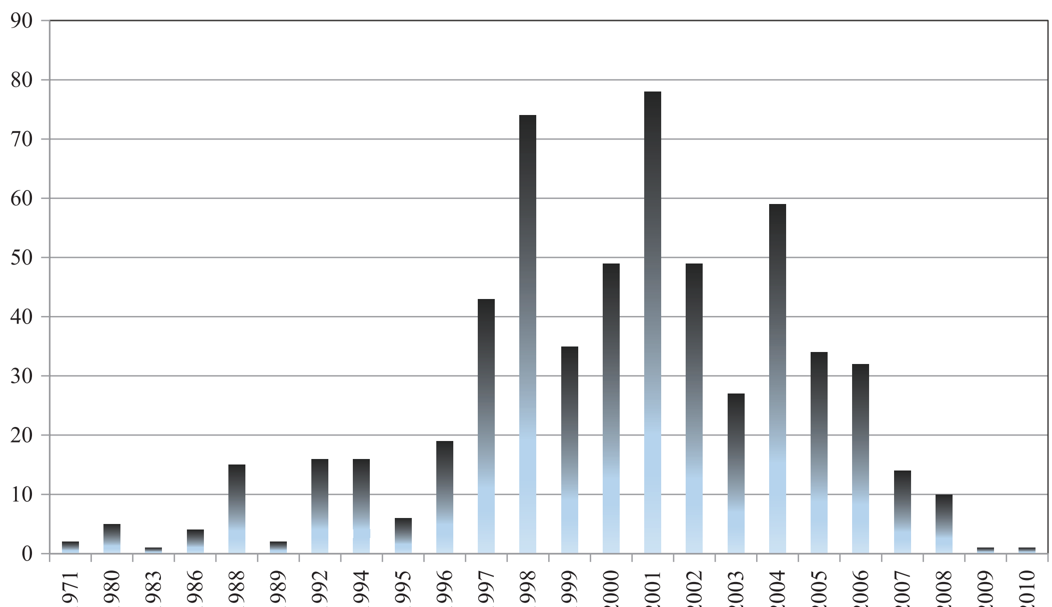
Exhibit 6 shows gross return multiples (TVPI) of portfolio companies as well as for investments made over the same periods for public equities and direct energy investments. The mean and median PE portfolio company does better than public equities or direct investments. However, the range of outcomes is much greater for portfolio company investments. For example, some investments are completely written off (multiple of 0.00), whereas the top 5% of portfolio companies generate multiples in excess of 7.00.

Exhibit 4
Number of Portfolio Companies by Sector and GP Investment

Sectors	N	%	% by GP Investment
E&P	348	56%	38%
Energy Services	136	22%	25%
Midstream	54	9%	15%
Power/Downstream	53	9%	19%
Alternatives	29	5%	3%
Total	620	100%	100%

Notes: This exhibit depicts the number of portfolio companies in the Adams Street Partners private equity dataset. Each row captures a different sector. The N signifies the number of companies, while the % signifies the percentage of the total number of companies in each sector. The % by GP Investment signifies the percentage of total GP invested capital in each sector.

Exhibit 5
Number of Portfolio Companies



Notes: This exhibit depicts the number of portfolio companies by original investment year in the Adams Street Partners dataset. The data consist of 620 companies derived from over 90 energy and natural resource-focused buyout funds.

Exhibit 6

Return Multiples of Portfolio Companies

	5%	25%	Median	Mean	75%	95%
PE Energy	0.00	1.08	2.10	4.57	3.42	7.44
ENG-VW	0.95	1.26	1.56	1.77	2.24	3.04
GSCI-E	0.52	0.90	1.43	1.65	2.07	3.45
WTI	0.84	1.25	1.66	1.83	2.20	3.31

Notes: This exhibit provides basic descriptive statistics for gross return multiples (TVPI) across PE energy portfolio companies (PE Energy), as well as public market energy stocks (ENG-VW) and commodities, such as the GSCI energy index (GSCI-E), and West Texas Intermediate (WTI) crude oil. Along with the mean, this exhibit reports the 5%, 25%, 50%, 75%, and 95% percentiles.

Exhibit 7

Fund-Level Correlations Using Cash Flow Data

	PE Energy	ENG-VW	GSCI-E	WTI
PE Energy	1.00	0.58	0.53	0.58
ENG-VW		1.00	0.79	0.81
GSCI-E			1.00	0.84
WTI				1.00

Notes: This exhibit provides fund-level correlations using internal rates of return for PE energy funds (PE Energy) and returns of "pseudo-funds" that invest in, and are distributed from, publicly available assets. To address some very skewed cash flows, we examine PE energy cash flows as described by Gredil, Griffiths, and Stucke [2014]. Investments are made into pseudo-funds on the same date as each PE fund in our sample. The publicly traded assets we consider are public market energy index (ENG-VW), the GSCI energy index (GSCI-E), and West Texas Intermediate (WTI) crude oil. Seven funds are excluded owing to short positions of the pseudo-funds.

ANALYSIS AND RESULTS

In this section, we use our dataset to explore the risk and return relations among energy investments. A critical element of any portfolio risk assessment is gauging the correlation between the returns on the assets within that portfolio. Higher correlations, for example, could signal higher contributions to overall portfolio risk.

Unfortunately, calculating correlations is not a straightforward task when considering private equity, because of its potential stale pricing problem and fund cash inflows and outflows. Conner [2003] defines a model of calculating the correlations between private equity index returns and public market index returns by unsmoothing the private equity index returns. Instead of using a private equity investment index, in this article, we propose a model based on cash flows, which does not require appraised quarterly values of funds for the correlation analysis, and thus avoids the smoothed pricing problem. The model uses actual contributions, distributions, and a final residual value to generate "pseudo-funds" of publicly available assets, which approximate the cash flow structure of the private equity vehicles. Specifically, our pseudo-funds match the dates and proportional amounts of contributions and distributions of energy PE funds, as if they were invested in and distributed from the public market ENG-VW index. A final valuation of the pseudo-fund is calculated accordingly. Some of the energy funds have significantly outperformed their corresponding public market indexes; consequently, a public market equivalent (PME) (or index comparison method as defined by Long and Nickels [1996]) could result in short positions during the life of the funds.[10] In order to address this shortcoming of the regular PME methodology, we again utilize the direct alpha methodology (Gredil, Griffiths, and Stucke [2014]) to adjust cash flows.[11]

Exhibit 7 depicts the correlations between oil and equity prices over the period 1986 to 2015. We find that both energy PE and public equity returns are positively correlated with oil prices. We also find that public equity returns tend to be more highly correlated with energy prices than are energy PE returns. This is evidenced by WTI's 0.58 correlation with PE Energy versus the 0.81 correlation with ENG-VW. Note that this difference is statistically significant (as our test rejects the hypothesis of equal correlation at better than the 1% confidence level).[12]

We complement the earlier analysis with a different tactic for standardizing the data in order to construct the correlation matrixes among our asset classes. In this exercise, we utilize portfolio company data through a simulation experiment. Specifically, fund returns are simulated by using the portfolio-company-level data with the assumption of 20 portfolio companies in a fund with investment dates that match up closely with those in fund vintage years. It is worth noting that although this approach for standardizing the return series is similar to the pseudo-fund approach, there are some important differences. The pseudo-fund approach is based on the internal rates of return of funds in different stages of their life cycle, which helps us to understand the impact of oil price movement on GP's valuation and cash flows. The simulation approach, on the other hand, focuses

Exhibit 8
Correlation Between Energy Price Movements and PE Energy Investments

	Portfolio Companies*				Simulated Funds^			
	PE Energy	ENG-VW	GSCI-E	WTI	PE Energy	ENG-VW	GSCI-E	WTI
PE Energy	1.00	0.24	0.12	0.14	1.00	0.38	0.18	0.22
ENG-VW		1.00	0.47	0.75		1.00	0.55	0.70
GSCI-E			1.00	0.73			1.00	0.76
WTI				1.00				1.00

Notes: This exhibit shows correlations between return multiples of private equity investment and other market benchmark indexes. The return multiple of a market index is calculated from the investment date of a company to its liquidation date. Correlations are presented at both the portfolio company level and simulated partnership fund level. Each simulated fund consists of 20 portfolio companies with investment dates within a three-year window centered in a given quarter of the sample period. Return multiples both for the simulated fund and for the corresponding market index are weighted by GP's investment commitments to each investment.

**Companies with TVPI > 10 are set to TVPI = 10 for computing returns used in correlation calculations of portfolio companies. ^Return multiples for both simulated fund and market index are weighted by GP's costs.*

on the relationship between oil price returns and final returns of investments in funds.

Exhibit 8 shows a correlation matrix for these factors based on final outcomes using the simulation approach. At an individual company level, the correlation between energy PE to oil (WTI) and energy (GSCI-E) returns are positive, but quite close to zero (0.14 and 0.12, respectively). Correlations are slightly higher for the simulated funds (0.22 and 0.18). In contrast, the value of a portfolio invested in public equity (ENG-VW) during the same time period is more correlated with energy price changes in general (about 0.5 with GSCI-E), and is highly correlated with changes in oil prices in particular (e.g., >0.7 with WTI). Our further analyses with portfolio company data and simulated fund data indicate that the final outcomes of energy PE are also less correlated with oil and energy prices than similar correlations for the public equity.

Next, we ask if commodity returns can explain the trajectory of public equity and energy PE returns. We explore this question by conducting a series of standard regressions with equity returns as the dependent variable and energy-based commodity returns as the explanatory variables. The energy PE returns considered in the regressions are the private equity IRR and the modified Dietz[13] TWRR (Dietz [1966]), while the public equity returns are the public market energy stocks (ENG-VW). Each of these dependent variables is observed at the quarterly frequency, and returns are calculated over a rolling three-year window. Specifically, the rolling three-year IRR is the three-year IRR calculated at each quarter-end using aggregated cash flows and net asset values across all funds. Rolling three-year TWRR is the modified Dietz TWRR, a time-weighted rate of return that takes into account the timing of the cash flow, calculated every quarter, and then compounded to a three-year return. This three-year return is calculated every quarter to create the rolling three-year TWRR. The dependent variables also are computed over a three-year rolling window. The data cover from 2000 Q1 through 2015 Q2, yielding 62 observations.

In Exhibit 9, we estimate six base specifications, which are depicted in odd-numbered specifications (i.e., columns labeled 1, 3, 5, 7, 9, and 11). Each of the three measures of equity returns are projected onto each of the two measures of commodity returns. Notice that attempting to include both commodity proxies (GSCI-E and WTI) in the same regression would produce a multicollinearity problem (as evidenced by the high unconditional correlations reported in Exhibits 7 and 8). In each specification, standard errors used for statistical inference have been corrected using the Newey–West method (Newey and West [1987]) with 12 lags.

In general, we find that energy-based commodity returns are good explanatory variables for energy-sector equity returns. However, oil prices are consistently better at explaining equity returns. This finding is supported by the greater statistical significance for WTI and higher adjusted R^2 for our linear specifications ranging as high as 0.48 for private equity and 0.61 for public market. Using the Bayesian information criterion (BIC) as a means of comparing explanatory power across models,

Exhibit 9

Regression Analysis of Returns

	Private Equity (IRR)				Private Equity (Modified Dietz TWRR)				Public Market Energy Stocks			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
GSCI-E	0.34*	0.89***			0.30	0.74***			0.39***	0.77***		
	[1.95]	[16.76]			[1.62]	[14.62]			[3.36]	[21.46]		
Recession Dummy		–0.15***		–0.08***		–0.17***		–0.12***		–0.06**		0.01
		[–3.65]		[–3.06]		[–4.01]		[–4.46]		[–2.40]		[0.37]
GSCI-E × Recession Dummy		–0.55***				–0.41**				–0.40***		
		[–3.00]				[–2.13]				[–3.35]		
WTI			0.81***	0.81***			0.78***	0.67***			0.65***	0.69***
			[3.52]	[16.95]			[3.34]	[14.54]			[4.42]	[18.34]
WTI × Recession Dummy				0.00				0.13				–0.05
				[–0.00]				[0.43]				[–0.29]
Intercept	0.15***	0.29***	0.08***	0.16***	0.16***	0.31***	0.09***	0.20***	0.09***	0.14***	0.04	0.03***
	[3.24]	[26.28]	[3.81]	[14.87]	[3.11]	[29.43]	[3.49]	[19.16]	[3.25]	[18.77]	[1.40]	[4.56]
Adjusted R^2	0.13	0.23	0.48	0.50	0.10	0.21	0.43	0.48	0.34	0.39	0.61	0.61
Root MSE	0.15	0.14	0.12	0.12	0.16	0.15	0.12	0.12	0.09	0.09	0.07	0.07
F-statistic	3.82	97.38	12.37	108.63	2.63	77.03	11.13	86.46	11.27	166.33	19.56	114.81
p-value (F-Test)	0.06	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

*Notes: This exhibit provides results from several ordinary least squares (OLS) specifications (with standard errors corrected using the Newey–West method) relating equity returns, both public and private, to commodity prices. The dependent variables are performance measures for private and public energy portfolio investments measured using quarterly three-year rolling returns (IRR and TWRR). The rolling three-year IRR is the three-year IRR calculated at each quarter-end using aggregated cash flows and net asset values across all funds. Rolling three-year TWRR is the modified Dietz TWRR, a time-weighted rate of return that takes into account the timing of the cash flow, calculated every quarter, and then compounded to a three-year return. This three-year return is calculated every quarter to create the rolling three-year TWRR. The independent variables are rolling three-year returns on WTI or GSCI-E Index from 2000 Q1 to 2015 Q2 (N=62), as well as a "dummy" variable that takes the value of 1 during the Great Recession (2007 Q4 to 2009 Q2). To correct standard errors for heteroskedasticity and autocorrelation, we use the Newey–West [1987] procedure allowing for 12 quarterly lags with quarterly three-year rolling returns of energy funds or public market energy index. t-Statistics are provided in brackets below each coefficient. ***, **, * denote statistical significance at the 1%, 5%, and 10% levels, respectively.*

we again find that WTI is typically better at explaining variation in equity returns.[14] For instance, with private equity IRR as the dependent variable, using WTI results in a root-MSE of 0.12 as compared with 0.15 when using the GSCI index. This finding holds for private equity TWRR, with a root-MSE of 0.12 versus 0.16, and public market equity, with a root-MSE 0.07 versus 0.09. Using this criterion, we also find that commodities are generally better suited for explaining public equity returns than they are for energy PE returns. To this point, we find MSE of 0.07 for the WTI explanatory variable when modeling public equity, versus 0.12 when modeling energy PE.

As noted, energy-based commodity returns enter positively into each of our regressions, implying that an increase in oil or energy returns is associated with an increase in public equity and energy PE returns. Despite the better fit for public equities, the linear models suggest similar factor exposures to energy prices for private and public equity. For example, if we focus on energy PE returns as measured by IRR, the coefficient on WTI in Specification (3) is 0.81, while the estimated coefficient for public equity in Specification (11) is 0.65. This finding holds for energy PE as measured by modified Dietz TWRR in Specification (7), where we obtain an estimate of 0.78. Across all specifications, WTI is a statistically significant factor for returns. Exposure estimates for GSCI-E are generally about half the magnitude of those for WTI and not always statistically different from zero. Overall, we find that a 1 percentage point increase in the return of WTI crude oil over a three-year rolling window is associated with a roughly 0.8 percentage point increase in energy PE returns, and a slightly lower percentage point increase in public equity returns.

As is evident in Panels A, B, and C of Exhibit 1, the Great Recession was a clear shock to the oil markets and the U.S. economy. We examine the importance of this unusual episode by creating a simple dummy variable that is equal to one for the NBER recession dates of 2007 Q4 through 2009 Q1 (and zero otherwise).

The results displayed in Exhibit 9 (even-numbered specifications) have two key features. First, the dummy variable for the Great Recession is always significant for private equity. Likewise, the joint significance of the regression explanatory variables (as measured by the F-statistics) jumps for the specifications including the recession dummy. For instance, the F-statistic increases from 12.37 for Specification (3), which includes only WTI, to 108.63 in Specification (4), which also includes the dummy variable. Overall, accommodating for the Great Recession markedly improves the goodness of fit for the energy PE specifications, with only marginal improvement for the public equity specifications.

The second finding in Exhibit 9 is that including the Great Recession does not appear to alter the economic relationship between energy-based commodities and equity returns. Each of the coefficients in WTI or GSCI-E remains positive and significant once we introduce the Great Recession. Moreover, our interaction terms are statistically insignificant, suggesting that the marginal impact of energy-based commodity returns upon equity returns does not depend upon whether the economy was in the Great Recession. Rather, the improved model fit seems localized to the constant term, implying that the Great Recession dummy allows our model to accommodate for higher/lower equity returns during that episode.

As an alternative to the OLS method with Newey–West corrections for standard errors, we also estimate a model based on generalized least squares (GLS) as described in Harri and Brorsen [2009]. In Monte Carlo studies, the GLS provide more efficient estimators of standard errors than OLS with Newey–West. Results from GLS estimates (not tabled) show similar, but statistically stronger, positive relationships between energy prices and equity returns. The GLS estimates reveal stronger relationships between energy prices and public market returns than with PE returns. We chose to report results based on Newey–West standard errors because they are unbiased (although typically less efficient than GLS estimates) and require less stringent assumptions for consistent estimates.

To further explore this question of why energy-based commodity returns impact those of equities, we note the long literature on the optionality of equity dating back to Merton [1974]. In our setting, equity might be thought of as an option on the underlying commodity. When viewed from this perspective, the relationship between equities and commodities might exhibit the convexities that are commonly found in the option pricing literature. For example, Toft and Prucyk [1997] note that the financial leverage implicit in a firm's equity might impact the value of this option on the underlying assets of the firm. Similarly, the energy companies might exhibit high degrees of operating leverage, wherein fixed costs are large relative to variables costs. In such situations, the abandonment option embedded in the equity of the firm should result in a nonlinear relation between energy prices and equity values. More generally, private equity firms have a variety of "real options" available to them, the values of which are connected to the flexibility provided to their owner. These options include timing options related to E&P operations as well as procurement and disposal of assets. This is consistent with evidence presented by Gredil [2015], who shows that PE managers have the ability to time capital deployments and realizations within their industry of specialization. Consequently, timing ability may offer an option-like payoff on the overall investments in a private equity portfolio. Finally, anecdotal evidence suggests that private equity firms frequently use nonlinear hedges to insure against financial distress that can be caused by low energy prices. In any of these cases, the embedded option characteristics suggest a nonlinear relationship between equity and energy-based commodity returns.

As a proxy for a nonlinear factor in the risk–return relationship, we include the squared terms on WTI and GSCI-E in our regression analyses. The even columns of Exhibit 10 display the results with the nonlinear terms, and the odd columns repeat the results from Exhibit 9 for the base case (for ease of comparison). For example, Specification (2) in Exhibit 10 projects IRR on GSCI-E and GSCI-E squared. This model form is repeated for each of the other regressions in the table. In each case, the adjusted-R^2 value rises when including the quadratic term; however, the improvements are modest for specifications with GSCI-E squared.[15] In contrast, the largest of differences are seen with an increase from 0.48 in Specification (3) to 0.55 in Specification (4), and 0.43 in Specification (7) to 0.51 in Specification (8).[16] Wald tests (not tabled) for model specification also indicate that across each of the six linear models, to include a quadratic term enhances explanatory power.

The relative importance of the quadratic term varies across the regressions. The relationship with GSCI-E

Exhibit 10
Regression Analysis of Returns

	Private Equity (IRR)				Private Equity (Modified Dietz TWRR)				Public Market Energy Stocks			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
GSCI-E	0.34*	0.39*			0.30	0.34			0.39***	0.44***		
	[1.95]	[1.87]			[1.62]	[1.61]			[3.36]	[3.24]		
$(GSCI\text{-}E)^2$		–0.52				–0.42				–0.50		
		[–0.56]				[–0.48]				[–0.95]		
WTI			0.81***	0.42**			0.78***	0.38*			0.65***	0.41***
			[3.52]	[2.12]			[3.34]	[1.73]			[4.42]	[4.26]
$(WTI)^2$				1.99***				2.08***				1.25***
				[3.37]				[2.97]				[3.25]
Intercept	0.15***	0.17**	0.08***	0.07***	0.16***	0.17**	0.09***	0.07***	0.09***	0.10***	0.04	0.03
	[3.24]	[2.45]	[3.81]	[3.48]	[3.11]	[2.39]	[3.49]	[2.99]	[3.25]	[2.70]	[1.40]	[1.18]
Adjusted R^2	0.13	0.14	0.48	0.55	0.10	0.11	0.43	0.51	0.34	0.36	0.61	0.66
Root MSE	0.15	0.15	0.12	0.11	0.16	0.16	0.12	0.12	0.09	0.09	0.07	0.07
F-statistic	3.82	1.87	12.37	14.68	2.63	1.33	11.13	12.99	11.27	5.88	19.56	24.90
p-value (F-Test)	0.06	0.16	0.00	0.00	0.11	0.27	0.00	0.00	0.00	0.00	0.00	0.00

*Notes: This exhibit provides results from several ordinary least squares (OLS) specifications (with standard errors corrected using the Newey–West method) relating equity returns, both private and public, to commodity prices. The dependent variables are performance measures for private and public energy portfolio investments measured using quarterly three-year rolling returns (IRR and TWRR). The rolling three-year IRR is the three-year IRR calculated at each quarter-end using aggregated cash flows and net asset values across all funds. Rolling three-year TWRR is the modified Dietz TWRR, a time-weighted rate of return that takes into account the timing of the cash flow, calculated every quarter, and then compounded to a three-year return. This three-year return is calculated every quarter to create the rolling three-year TWRR. The independent variables are rolling three-year returns on WTI or GSCI-E Index (including squared values) from 2000 Q1 to 2015 Q2 (N=62). To correct standard errors for heteroskedasticity and autocorrelation, we use the Newey–West [1987] procedure allowing for 12 quarterly lags with quarterly three-year rolling returns of energy funds or public market energy index. t-Statistics are provided in brackets below each coefficient. ***, **, * denote statistical significance at the 1%, 5%, and 10% levels, respectively.*

returns appears to be linear in each case as the quadratic terms are not statistically different from zero. In contrast, both public equity and energy PE returns have a significant nonlinear relation to WTI. The relationship is somewhat stronger for energy PE than for public equity. Visually, this nonlinear relationship is depicted in Exhibit 11. As WTI prices rise, equity returns increase at a faster rate. In fact, the sensitivity of performance to WTI price changes is close to zero when returns are low. The results indicate that the performance of (especially private) equity in the energy sector is not very correlated with oil prices when multiyear returns of crude oil are low. But when oil returns are high, equities have a higher sensitivity to energy prices, and therefore both public equity and energy PE returns appear to capture significant upside. As discussed previously, this finding is consistent with the hypothesis that significant operating or financial leverage of portfolio companies, market-timing ability, or other real options available to public energy companies and energy PE fund (or PE fund portfolio company) managers are able to generate option-like investment returns. The somewhat stronger nonlinearities exhibited by energy PE funds suggest that these effects might be greater for investments in these funds. However, it is important to note that these results hold at multiyear return horizons but not at the quarterly frequency. It may take more than a few quarters for reported returns in private funds to fully reflect the economics of energy price changes. This could be the result of delays in marking portfolio assets or uncertainty in terms of how prices will affect asset values.

CONCLUSIONS

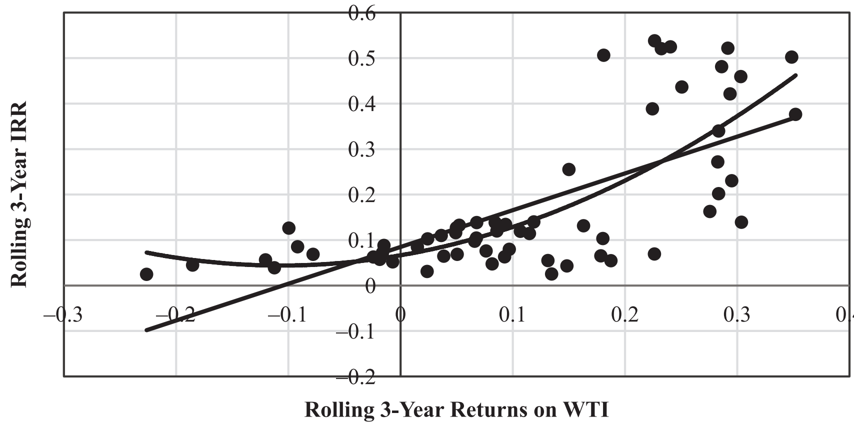
This study sheds light on the historical risk and return relationships between oil price movements, broader energy prices, and both private and public market energy investments. From the perspective of final outcomes, the data show that investments in energy PE funds have a significantly lower correlation to the oil price movements than do public equity investments.

However, when interim period returns are considered, the impact of the oil price movement on these investments becomes less straightforward. For energy

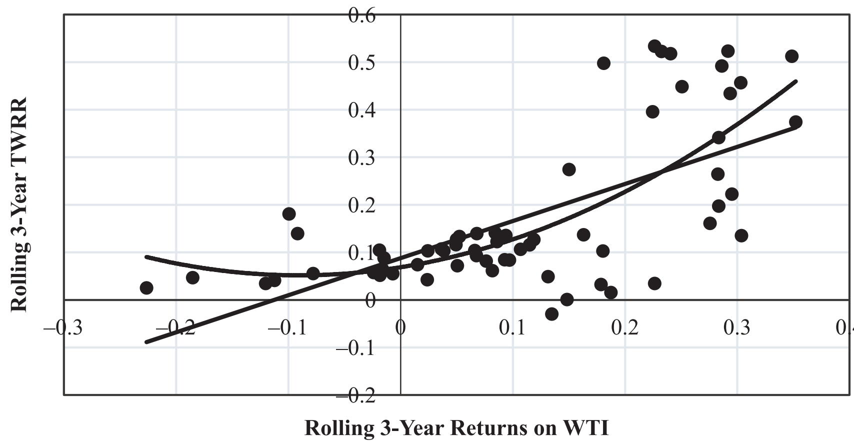
EXHIBIT 11

Scatter Plots and Regression Results

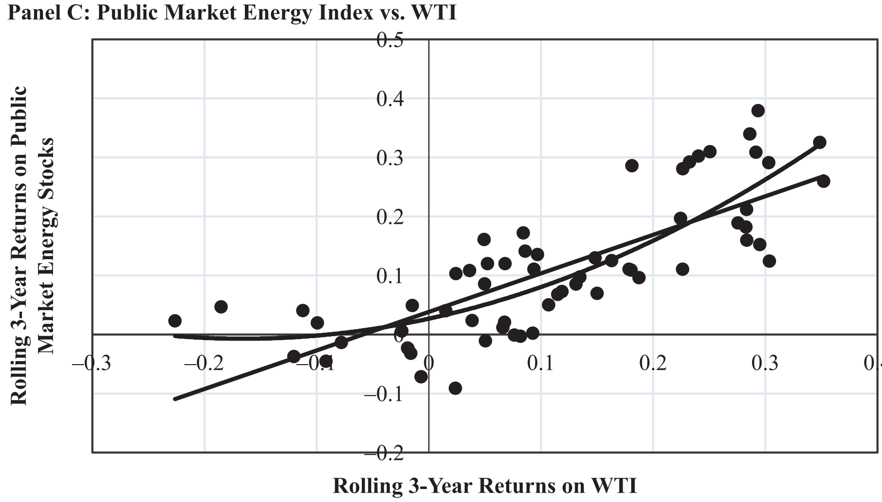
Panel A: PE fund IRR vs. WTI



Panel B: PE fund TWRR vs. WTI



Panel C: Public Market Energy Index vs. WTI



Notes: Each panel in this exhibit depicts the relationship between WTI crude oil and equity returns over the period 2000 Q1 to 2015 Q2. The regression specifications are detailed in Exhibit 10, which include linear and quadratic explanatory variables. Panel A regresses private equity IRR on WTI, Panel B regresses private equity TWRR on WTI, and Panel C regresses public equity on WTI.

PE, the evidence suggests that the relationship between broad energy prices (as measured by GSCI-E) and returns is linear. However, the relationship between energy-focused equity returns (both public and private) and WTI price changes appears convex. This suggests that energy-focused equity investments have been able to capture upside in U.S. oil prices. The effect is stronger for energy PE than for public equity, and this explains, in part, why private equity fund returns exceed public equity returns during our sample period. An important caveat to this conclusion is that this is a relatively new investment category. As such, we have quite a limited amount of historical data for PE energy funds. Thus, these results are primarily driven by the period between 2000 and 2015, which was somewhat unusual in the magnitude of energy price swings. The nonlinear effects, if any, at shorter horizons may be obscured by noisy or stale quarterly PE fund valuations.

There are some theoretical reasons to believe that energy PE funds have investment profiles with a better potential to capture the upside of energy price movements compared with their public equity counterparts. For example, operating leverage and flexibility in portfolio companies may generate more "real option" value in a PE structure. In other words, funds may be more like a portfolio of options versus an option on a portfolio (which in general has lower value than the portfolio of options). Likewise, investment timing options and financial leverage could also create a more convex (e.g., option-like) return profile for energy PE funds. Overall, these results suggest somewhat differing risk and return profiles for different investment strategies related to energy. In particular, the results suggest that investors seeking short-run speculative exposure to energy prices would have benefited most by constraining themselves to direct energy-based commodity investments. Investors with an intermediate-term view on energy exposure and a strong liquidity preference would have likely preferred public equities in the energy sector. Investors seeking higher returns and diversification (or with a long-term view on energy), and willing to tolerate lower liquidity, would have benefited most from allocating disproportionately to energy PE funds.

ENDNOTES

[1]For key examples, see Jensen, Johnson, and Mercer [2002]; Bessler and Wolff [2015]; and Chong and Miffre [2010].

[2]For example, several large investment banks lowered their oil price targets during the summer of 2015 in the aftermath of weak Chinese economic data: http://www.reuters.com/article/2015/08/14/us-oil-price-forecasts-citi-idUSKCN0QJ1O120150814.

[3]http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mttstus1&f=m.

[4]http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_5.pdf.

[5]Simon [2013] finds that the correlation between energy-focused public equities and commodities is large. Haigh, Hranaiova, and Overdahl [2007] suggest that hedge funds might exacerbate this co-movement.

[6]We document this result subsequently in our data analysis.

[7]Results presented in this article are from a joint venture between Adams Street Partners (practitioner), Burgiss (data analytics), and the UNC Kenan–Flagler Business School (academic). We attempt to address the oil-energy investment correlation issues referenced earlier. Data gathered by Adams Street Partners do not reflect Adams Street Partners' performance and do not represent a full private equity dataset.

[8]S&P Dow Jones Indices acquired the GSCI franchise from Goldman Sachs on February 2, 2007. The current version of the S&P GSCI index was adopted on May 7, 2007. All values before this date used in our analysis are as reported in October 2015 by S&P. The S&P GSCI is a production-weighted index, designed to reflect the relative significance of each of the constituent commodities to the world economy. Consequently, weights will change over time based on a rolling five-year averaging of production. As of October 2015, the GSCI energy index had the following approximate weights: WTI crude oil is 34.3%, Brent Crude oil is 34.7%, Gas Oil is 10.4%, Heating Oil is 8.2%, RBOB Gasoline is 8.0%, Natural Gas is 4.4%. Details of the index weight methodology are available at us.spindices.com/indices/commodities/sp-gsci-energy.

[9]At least 90% of the value of the investment has been returned.

[10]The most common method for calculating PMEs is described in Kaplan and Schoar [2005]. PMEs compare how much a PE fund investor actually earned net of fees to what the investor would have earned in an equivalent investment in a comparable public market index. The calculation discounts all distributions and residual value of the fund to the same point in time using the public market returns and expresses the discounted values as a ratio of distributions to contributions. The index comparison method (ICM) is an IRR-based methodology by comparing returns of private equity investment with returns from public market investment. It assumes buying and selling the public market index according to the timing and size of the cash flows of the private equity investment. ICM provides a direct

opportunity cost comparison of how net funds invested in the private investment would have performed had they been invested in the stated index over the life of the particular investment.

[11]The direct alpha method is an IRR-based annualized excess return, describing the relative performance of the private market investment to the stated index as of the measurement date.

[12]The test for equality of two correlation coefficients drawn from two different samples has a null hypothesis that the coefficients are equal. The resulting test statistic is −4.395, with an associated p-value of <0.01, indicating that we reject the null, thereby suggesting that these correlations are very likely to be different.

[13]A measure of the historical performance of an investment portfolio in the presence of external flows.

[14]When using the Bayesian information criterion as a means of model comparison, smaller values imply better model fit. For instance, with the private equity IRR as the dependent variable, WTI has a BIC of −84.41 versus the −53.17 for GSCI, implying that WTI seems to offer a better model fit. This finding holds for private equity TWRR, with BICs of −76.67 versus −48.70, and public market equity, with BICs of −143.28 versus −111.40. By applying this same criterion to non-nested model selection, we also find that commodities are generally better suited for explaining public equity returns than they are for energy PE returns.

[15]RESET tests for model misspecification support the inclusion of a quadratic term for WTI at the 1% confidence level in all cases. Similar tests for model misspecification provide mixed evidence for the inclusion of a quadratic term for GSCI-E.

[16]F-test from nested regressions show that the differences from both cases are statistically significant at the 5% confidence level.

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