Calendar Spreads vs. Price Is There A Relationship?

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Many traders assume that calendar spreads show a relationship to prices. Are these assumptions correct? If so, how well do the spreads track prices, and is the relationship helpful?

To find out, four spreads for the NYMEX light sweet crude oil and natural gas futures contracts were evaluated: First-to-second nearby contract months, second-to-third, first-to-sixth, and first-to-13th. The first-to-13th spread compares like calendar months, such as January to January, eliminating seasonal issues. These spreads were evaluated for crude oil futures prices from January 1986 and natural gas futures from April 1990 to February 2008.

Two major categories relating to the spreads were calculated. These were an evaluation of the spreads versus price direction and price rate of change (bias), and an evaluation of the rate of change of the spreads versus price direction and bias.

Evaluation of Spreads

The spreads were evaluated on an absolute dollar basis as well as percent of price, where the dollar amount of the spread was divided by the average of the two underlying prices upon which it was based. The odds of the market going up, and the bias, were evaluated over a series of 10-day periods which were either concurrent dates or offset; that is, the spread over the 10 days up to and including the current day versus the bias over the following 10 days.

Several calculations were made for each date: the dollar value of the spread, the spread in terms of percent of price, price direction 10 days back or forward, and the change in price in terms of dollars and percent back or forward were calculated.

To clarify a fine point, the percent of price was based on an average of the two prices in the spread. The actual change in price was based on the first nearby contract. As an example, if the first-to-13th spread was being evaluated, and the actual prices were $6.00 and $4.00, for an average of $5.00, the spread is $2.00 or 40% of the price.

The redacted light sweet crude oil futures first-to-13th table (Figure 1) shows typical results for an "offset" evaluation. Column 1 is the percentile ranking for column 2, the spread in dollars. Column 3 is the percent that prices went up, and column 4 is the rate of change. So, for example, at the fifth percentile the spread was ($3.73). That bin, or percentile range, contains spreads ranging from greater than ($5.69) to equal to ($3.73). Prices went up 54% of the time, but the bias was negative $0.03. This means that the amount that prices went down 46% of the time outweighed the amount the prices went up 54% of the time by $0.03. Columns 5 through 7 provide similar values as a percentage of price.

The next step was an analysis of the coefficients of determination, commonly known as R-squareds, or R^2, also informally called "regression analysis" or "correlations." It also measured whether the F-statistic – also called the f-stat – which is a measure of statistical significance, was significant for each R^2.

A significant f-stat indicates that there is a statistically significant relationship between the variables. If the f-stat is too low, then the findings may be unreliable. In addition to the R^2 and f-stat, in cases where the f-stat was high enough, a best fit curve in the form of $y = mx + b$ was calculated.

The first iteration involved setting up rank and percentile tables as shown in Figure 1. The small number of data points did not yield statistically significant results. Therefore, a second iteration was performed with the bins broken into 100, one-percentile increments.

Even with 100 bins, some results still lacked significance. Bad f-stats can result from not enough data, extreme outliers, or just poor correlation. The first possibility was ruled out by many significant observations. Thus, two additional runs were performed that removed the outliers. These runs slightly improved the f-stat for some observations but lowered others and so outliers were ruled out as a reason for low f-stats and attributed to poor correlations.

Spread Findings

The first-to-second month and second-to-third month spread relationships were erratic, poorly correlated, and had many bad f-stats, even with the outliers thrown out. Thus these finding are considered uncorrelated. Seasonality and resultant irregular rollover gaps may be why the correlations are inconsistent. Calendar-based studies (January versus February, March versus April) as opposed to positional studies (first nearby versus second nearby) may yield better results, but such an analysis is outside the scope of this article.

The first-to-sixth nearby and first-to-13th studies were all statistically significant and consistent between the concurrent and offset analyses, dollar and percent results and natural gas and crude oil. The first-to-sixth nearby spreads are always two seasons apart and change gradually, and the first-to-13th spreads are a full yearly cycle apart.

In Figure 1, the relationships between the spread and direction or with bias, look poor. The R^2s are about 0.07 for the percent up, and 0.20 for bias. The low R^2 values confirm the very weak correlations and mean current spreads aren't useful in predicting future direction or price.

Even though spread prices may not be predictive, the question still remains as to whether spreads track concurrent prices. So rather than looking at spreads relative to future prices, the current spread correlations were compared with past market direction and past bias. Here the answer is different.

Crude Oil 1st to 13th Nearby Spread vs. Next 10-Day Percent Up and Rate of Change

(Figure 1)

1 Percentile	2 Spread $	3 % Up	4 Bias $	5 Spread %	6 % Up	7 Bias %
2.5	(5.69)	57	0.45	(15.6)	67	3.22
5	(3.73)	54	(0.03)	(12.6)	51	0.31
10	(2.39)	62	0.81	(9.2)	53	0.95
15	(1.70)	50	0.11	(6.3)	44	(0.38)
20	(1.08)	49	0.18	(4.1)	56	2.19
25	(0.55)	52	0.11	(2.5)	56	0.56
30	(0.21)	53	(0.08)	(1.0)	55	0.48
35	0.03	45	(0.03)	0.2	42	(0.07)
40	0.32	55	0.12	1.7	55	0.97
45	0.60	57	0.12	3.1	57	1.02
50	0.84	56	0.05	4.2	61	1.10
55	1.08	57	0.05	5.2	57	0.59
60	1.40	55	0.15	6.2	53	0.40
65	1.89	52	0.19	7.6	54	0.61
70	2.48	57	0.43	9.6	56	0.19
75	3.01	61	0.46	11.5	53	0.84
80	3.70	54	0.37	13.7	60	1.66
85	4.43	56	0.25	15.7	59	0.87
90	5.19	48	(0.14)	18.8	43	(0.90)
95	6.39	47	0.02	23.2	49	(0.16)
97.5	7.76	54	0.14	27.4	48	(0.34)
100	13.39	34	(2.23)	39.7	32	(6.09)

Crude Oil 1st to 13th Nearby Spread vs. Last 10-Day Percent Up and Rate of Change

(Figure 2)

1 Percentile	2 Spread $	3 % Up	4 Bias $	5 Spread %	6 % Up	7 Bias %
2.5	(5.69)	33	(1.40)	(15.61)	24	(4.57)
5	(3.73)	52	0.05	(12.61)	28	(3.39)
10	(2.39)	47	0.48	(9.15)	34	(1.95)
15	(1.70)	34	(0.37)	(6.33)	54	0.30
20	(1.08)	52	0.04	(4.12)	45	(0.27)
25	(0.55)	35	(0.29)	(2.53)	45	(0.17)
30	(0.21)	43	(0.19)	(1.03)	49	(0.60)
35	0.03	48	(0.08)	0.17	49	0.04
40	0.32	43	(0.18)	1.74	44	(0.21)
45	0.60	49	(0.05)	3.07	43	(0.72)
50	0.84	50	(0.00)	4.16	47	0.19
55	1.08	58	0.12	5.22	52	0.52
60	1.40	67	0.19	6.21	64	1.14
65	1.89	63	0.08	7.65	70	2.22
70	2.48	53	(0.18)	9.56	60	1.13
75	3.01	50	(0.13)	11.46	60	1.04
80	3.70	53	(0.06)	13.68	56	0.98
85	4.43	52	(0.19)	15.73	60	1.07
90	5.19	65	0.55	18.79	63	1.63
95	6.39	76	1.28	23.21	65	2.33
97.5	7.76	79	1.87	27.39	72	3.72
100	13.39	84	2.34	39.70	80	5.97

Figure 2 is the same as the previous table, except that it is for concurrent data. A review shows much better correlations, especially in the bias columns.

The R^2's increase to 0.43 and 0.60 for the percent up, on a dollar and percent basis, and to 0.43 and 0.65 for bias. So spread versus percent up and bias correlate and the relationships for the percent-based values are at least close to the 0.70 R^2 that some recommend for a minimum.

Figure 3 summarizes the R^2 for the offset dates, all low, and the concurrent dates, much higher, with the results for the natural gas futures first-to-13th nearby contracts above 0.70, at 0.79. So, while the data is correlated, it's inadequate for trading.

Evaluation of the Rate of Change

The next portion of the study evaluated the rate of change of the spreads against the same two criteria of market direction and bias. The rate of change was always evaluated either for the concurrent 10-day periods or the offset 10-day periods. The data was then evaluated similarly to the spreads, as discussed relative to Figure 3.

Note that the rate of change was evaluated relative to percent of price, as the spreads were. While the study originally attempted to look at the rate of change relative to the spread dollar value, since the spread can be zero or close to zero, the rate of change can be pushed towards infinity.

Rate of Change Findings

For the rate of change study, the offset and future correlations were all poor, and five of the 32 observations – shown in red on Figure 4 – weren't statistically significant. However, all of the concurrent results were statistically significant, and many were above 0.70. The R^2 for the percent-based correlations were consistently better than the dollar based, and the first-to-second and second-to-third nearby spread results were consistently worse than the first-to-sixth and first-to-13th.

With good correlations it is possible to fit a straight line having the form $y = mx + b$ to the data. The cutoff point for a good R^2 is usually 0.80 or 0.85, but that is arbitrary. Traders might want to use 0.70 for estimating percent up, since that is just for market direction, while 0.80 or 0.85 might be more prudent for bias, since that is predicting the rate of bias. So, using best-fit curves for any data set that has less than a 0.70 or 0.80 would be considered a bad idea by most industry guidelines.

R^2 Results for Spread vs. Percent Up and Bias Analysis

(Figure 3)

(CL=NYMEX light sweet crude oil futures; NG=NYMEX natural gas futures)

Offset Dates			Concurrent Date Rage		
PercUp					
R^2 Dollar	1 to 6	1 to 13	R^2 Dollar 1 to 6	1 to 13	
NG	0.10	0.09	NG	0.24	0.39
CL	0.08	0.07	CL	0.42	0.43
R^2 Percent	1 to 6	1 to 13	R^2 Percent	1 to 6	1 to 13
NG	0.19	0.10	NG	0.46	0.64
CL	0.09	0.06	CL	0.58	0.60
Bias					
R^2 Dollar	1 to 6	1 to 13	R^2 Dollar 1 to 6	1 to 13	
NG	0.33	0.29	NG	0.38	0.67
CL	0.17	0.19	CL	0.42	0.43
R^2 Percent	1 to 6	1 to 13	R^2 Percent	1 to 6	1 to 13
NG	0.39	0.21	NG	0.55	0.79
CL	0.29	0.21	CL	0.62	0.65

R^2 Results for Rate of Change of Spread vs. Percent Up and Bias Analysis

(Figure 4)

(CL = NYMEX light sweet crude oil futures; NG = NYMEX natural gas futures)

	Offset Dates				Concurrent Date Range				
Percent Up									
R^2 Dollar	1 to 2	2 to 3	1 to 6	1 to 13	R^2 Dollar	1 to 2	2 to 3	1 to 6	1 to 13
NG	0.02	0.01	0.05	0.06	NG	0.20	0.09	0.32	0.37
CL	0.01	0.001	0.02	0.01	CL	0.30	0.29	0.70	0.65
R^2 Percent	1 to 2	2 to 3	1 to 6	1 to 13	R^2 Percent	1 to 2	2 to 3	1 to 6	1 to 13
NG	0.14	0.01	0.15	0.24	NG	0.67	0.46	0.70	0.75
CL	0.07	0.00	0.06	0.02	CL	0.77	0.78	0.83	0.80
Bias									
R^2 Dollar	1 to 2	2 to 3	1 to 6	1 to 13	R^2 Dollar	1 to 2	2 to 3	1 to 6	1 to 13
NG	0.20	0.20	0.00	0.00	NG	0.52	0.30	0.81	0.85
CL	0.27	0.04	0.09	0.03	CL	0.80	0.72	0.97	0.97
R^2 Percent	1 to 2	2 to 3	1 to 6	1 to 13	R^2 Percent	1 to 2	2 to 3	1 to 6	1 to 13
NG	0.17	0.02	0.12	0.11	NG	0.80	0.73	0.94	0.98
CL	0.13	0.00	0.14	0.09	CL	0.92	0.96	0.99	0.99

If the R^2 is high enough and a trader is experienced in predicting spreads, but not price, he can make a reasonable estimate on price by using the rate of change to estimate the bias, or vice versa.

Focusing on the concurrent date data, best-fit curves yield the line formulas shown on Figure 5. Note that the percent up formulas must be bound by 0 and 100 even if values generated by the formulas at the extreme yield values fall outside these boundaries. Also the "percent" formulas are actually fractions, so for percent, multiply by 100.

A trader should not use correlations less than his cutoff, say 0.70 for the percent up and 0.85 for the bias. Keep in mind that the best-fit curves are an approximation and only provide an expected estimate.

Summary of R2 and Formulas for Rate-of-Change Analysis

(Figure 5)

Percent Up				
R^2 Dollar	**1 to 2**	**2 to 3**	**1 to 6**	**1 to 13**
NG	0.20	0.09	0.32	0.37
	0.235 * x + 0.508	0.309 * x + 0.482	0.370 * x + 0.504	0.496 * x + 0.502
CL	0.30	0.29	0.70	0.65
	0.321 * x + 0.423	0.665 * x + 0.342	0.298 * x + 0.521	0.235 * x + 0.519
R^2 Percent	**1 to 2**	**2 to 3**	**1 to 6**	**1 to 13**
NG	0.67	0.46	0.70	0.75
	7.063 * x + 0.514	9.500 * x + 0.515	6.744 * x + 0.502	8.555 * x + 0.493
CL	0.77	0.78	0.83	0.80
	29.003 * x + 0.518	65.060 * x + 0.516	20.610 * x + 0.515	16.003 * x + 0.513
Bias				
R^2 Dollar	**1 to 2**	**2 to 3**	**1 to 6**	**1 to 13**
NG	0.52	0.30	0.81	0.85
	0.501 * x + 0.000	0.396 * x + 0.006	0.749 * x + (0.014)	0.928 * x + (0.015)
CL	0.80	0.72	0.97	0.97
	1.735 * x + 0.058	3.322 * x + 0.038	1.664 * x + 0.054	1.326 * x + 0.042
R^2 Percent	**1 to 2**	**2 to 3**	**1 to 6**	**1 to 13**
NG	0.80	0.73	0.94	0.98
	2.053 * x + 0.008	2.432 * x + 0.008	1.811 * x + 0.004	2.211 * x + 0.002
CL	0.92	0.96	0.99	0.99
	4.966 * x + 0.003	9.892 * x + 0.003	3.368 * x + 0.002	2.575 * x + 0.001

Figure 6 shows some actual versus estimated data for NG first to 13th, using "min(max(8.555 * x + 0.493,0),1)" for the percent up and "2.211 * x + 0.002 for bias." The table shows for nearly 18 years of natural gas data, there have been no instances where the spread dropped by more than 6% and the market went up. The upper end of the data is less reliable, but the odds for the top third of the observations average 94% actual versus 84% estimated.

A best-fit curve relative to actual data for natural gas first-to-13th spread

NG 1st to 13th Rate of Change Actual vs. Estimated Percent Up and Bias

(Figure 6)

Percentile	ROC	Actual % UP	Estimated % UP	Actual Bias	Estimated Bias
1	(0.126)	0	0	(0.25)	(0.28)
6	(0.061)	0	0	(0.13)	(0.13)
10	(0.047)	0	9	(0.12)	(0.10)
20	(0.027)	11	26	(0.05)	(0.06)
30	(0.017)	11	35	(0.04)	0.00
40	(0.008)	37	42	(0.01)	0.00
50	(0.000)	58	49	0.01	0.00
60	0.009	75	57	0.02	0.02
70	0.018	95	65	0.06	0.04
80	0.032	93	77	0.07	0.07
90	0.054	98	96	0.13	0.12
95	0.077	91	100	0.16	0.17
100	0.297	87	100	0.29	0.66

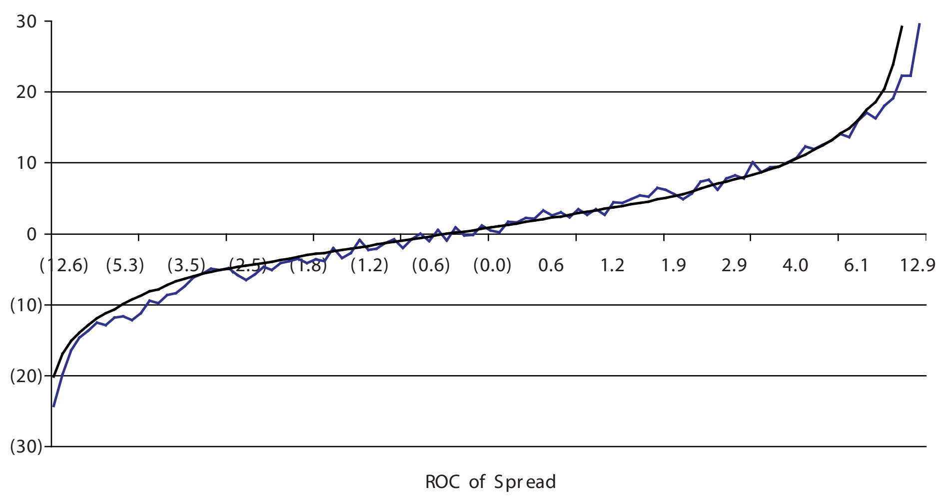
rate of change versus price bias in terms of percent of price is represented by Figure 7. The reason that the data is not a straight line is due to the fact that the rates of change are taken from the percentile bins and thus, while the percentiles are even, the rates of change associated with them are not.

Here are two examples of how the information above might be used. Let's say the natural gas, first and 13th nearby contracts are trading at $9.00 and $10.00. A trader is familiar with forecasting discrete prices, and calls the first nearby up by $0.70 or 7.4% of underlying (0.7/9.5). The spread, then, can be estimated by transposing the formula from y = 2.211 * x + 0.002 to x = (y / 2.211) – 0.002, remembering that these formulas are based on fractions, not percents. With this formula, the estimated rate of change is 3.15%, or $0.30, increasing the spread from $1.00 to $1.30, which, with the first nearby at $9.70, gives the 13th at $1.30 over, or $11.00. So if the trader is right about the first nearby, reasonable estimates of both the spread and the value of the 13th nearby can be made.

Now, let's look at a crude oil example, using the first-to-second month spread, which is $0.50 over the current average price of $100. The spread is estimated to fall $1.00, to $0.50 under, for a drop of 1%. If using the formula y = 4.966 * x + 0.003, then a drop in price of $4.70 is

NG 1st to 13th Spread Rate of Change vs. Bias in Terms of Percent of Price

(Figure 7)



called for. So, on average, the first nearby contract is estimated to fall to $95.8 ($100.50 - $4.70), and the second nearby would then be $95.80 + $0.50, or $96.30, and the odds of a decline taking place is 1 – (29.003 *-0.01 + 0.518), or 77%.

Suggestions for Further Study

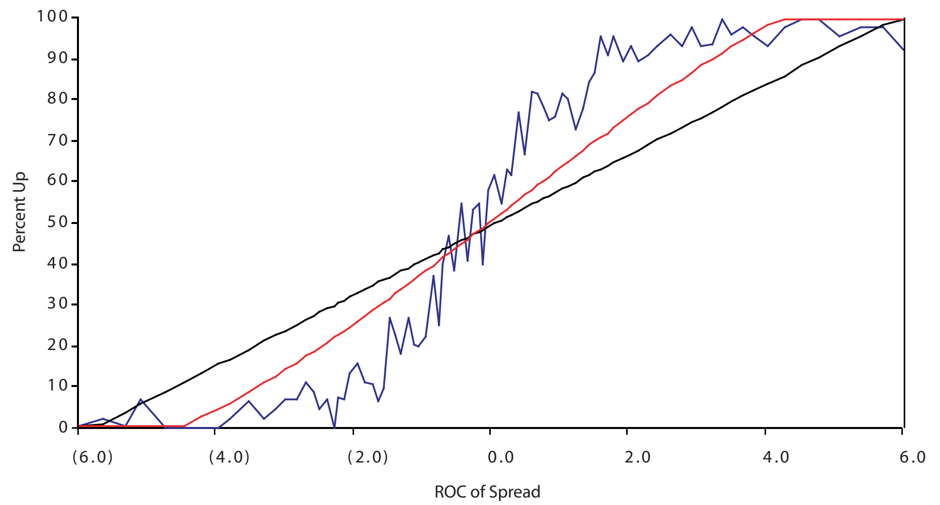
Some further refinements might be made to see whether correlations can be improved. For example, rather than dividing by the average price to get the percent of price, the price of only the first nearby contract might be used. Also, the study, as mentioned earlier, evaluated the data over 10-day periods. Different periods, for example, from three days, to maybe 20 days or more might be examined to see how the correlations hold up. As mentioned earlier, discrete calendar month pairs might also be studied.

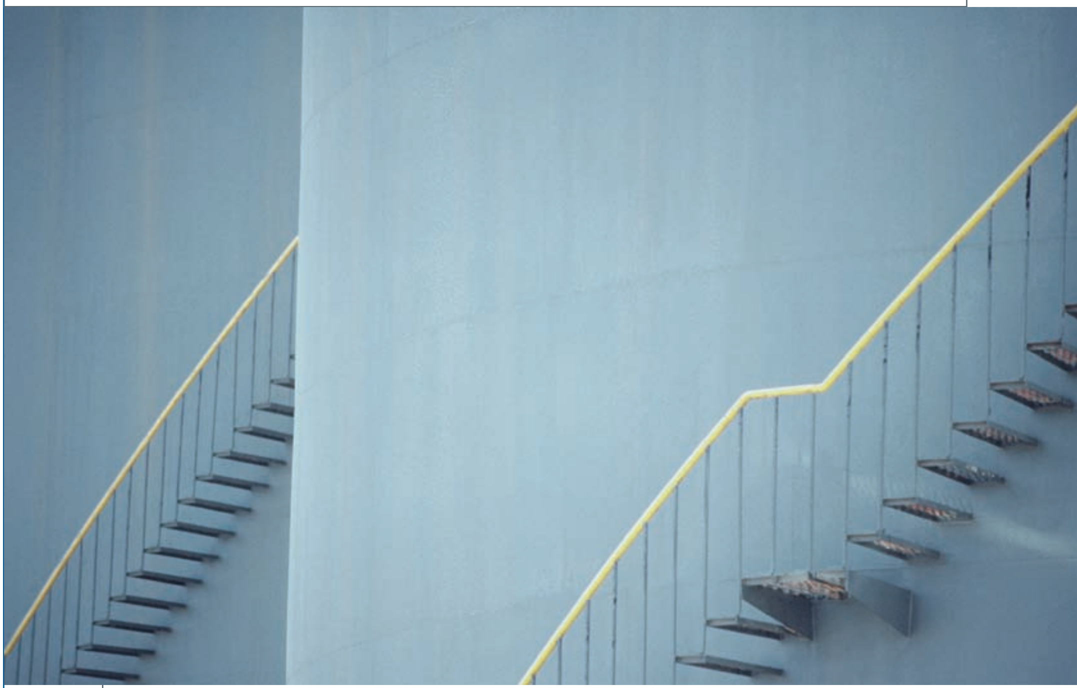
In addition, different best fit formulas, other than straight lines might be tested, especially for the percent up. For example, the natural gas first to 13th percent up R^2 was 0.75. Figure 8 shows the actual data in dark blue, and the linear fit in black. As can be seen, the data forms a slanted S shape relative to the linear fit. Thus, other methods such as a cubic fit which has the form y = m1*x3 + m2*x2 + m3*x +b could be examined for all the relationships. When tested on the data below, the formula y = -764.91*x3 + 4.81x2 + 12.9*x + 0.50 gave a closer fit to the data as shown with the red line, and yields an R^2 of 0.88 versus the linear 0.75. So an analysis of all the relationships on this basis may be justified.

In conclusion, neither spreads nor rate of change of spreads are predictive of future price activity. However, both spreads and the rate of change of the spreads correlate with market direction and the rate of change of price. While spreads don't correlate well enough to be a useful tool in making predictions, the rate of change of the spreads do correlate well enough with rate of change of price, that if one variable can be predicted, the other may be estimated.◆

NG 1st to 13th Spread Rate of Change in Terms of Percent of Price vs. Percent Up

(Figure 8)





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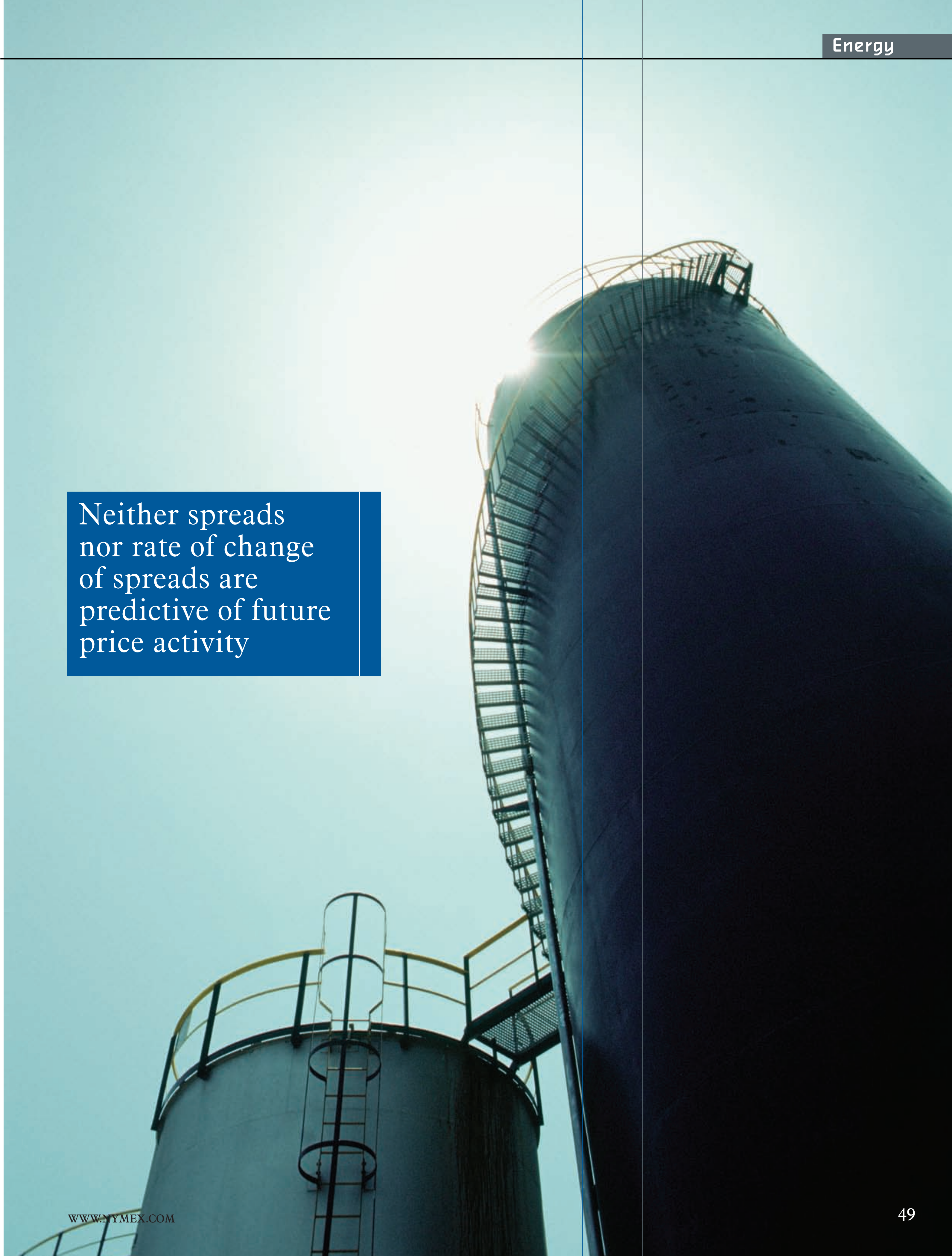

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