Deutsche Bank

Global Markets Research

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Signal Processing

Oil shock: A quant perspective

Research Summary
In this report we build a better oil price beta. We show how our new beta can help investors measure the sensitivity of a stock's returns to movements in the oil price more accurately.

A quantitative approach to measuring oil price sensitivity

Building a better oil price beta
One again the price of oil is caught up in a nexus of political and economic uncertainty. In this report we develop a better way to measure a stock's sensitivity to oil price movements. The enhanced oil beta that we develop is less backwards-looking than the traditional regression beta, and does a better job at capturing future oil price sensitivity.

The power of the news
We use a novel database of oil-related news stories to measure how stocks react in the short-term to positive and negative news stories about oil. Combining this short-term news beta with the traditional beta enhances performance.

Shock therapy
We further enhance our oil beta by incorporating a stock's reaction to large one-day jumps or falls in the price of oil. Oil price shocks are, somewhat surprisingly, quite different from oil news events, and as a result incorporating a stock's past reaction to price shocks incrementally improves our new oil beta.

Practical tools for non-quant inventors
We include a list of stocks with a high positive and negative sensitivity to oil, based on our enhanced beta methodology. We also present two tradable baskets, one which we expect to outperform if oil prices rise (DBUSOILP) and one which should do well if oil prices fall (DBUSOILN).

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A letter to our readers

Building a better beta to oil prices

Our recent research has focused on two themes: incorporating macro data into models, and the blurred boundary between alpha and risk

Two important themes have dominated our recent research. First, we have spent a lot of time looking at how the macroeconomic environment influences quantitative investing strategies. Our ideas on this front range from what we would call proactive strategies – for example dynamic factor rotation – to more defensive strategies, such as factor neutralization.

A second theme that has emerged more indirectly from our research is that the line between alpha and risk is becoming increasingly blurred. Strategies that help control risk can indirectly help boost alpha, and vice versa. A case in point is our recent work on robust factor models. There we found that having a better factor covariance matrix not only helps control risk, but also confers a useful side benefit: it helps steer the alpha model towards quant factors that are best suited to a particular risk regime, thereby improving stock return prediction. On the other side of the coin, our work using options data as an alpha factor suggested that the options market can be a useful leading indicator of downside risk.

Conditional alpha

In this report we look at better ways to measure a stock's sensitivity to oil price movements

This research report expands on these two themes. Usually our *Signal Processing* research series is devoted to finding new alpha factors, but this month we depart a little from this agenda by examining what we might call a conditional alpha factor – a stock's beta to oil price movements. We call this a conditional factor because the use of the factor -- at least on the alpha side of the equation -- is conditional on one's view about future oil prices. However, returning to the second theme we mentioned, the oil price beta is another good example of a metric that is useful for risk control as well as alpha generation. For example, even if one has no view on forward oil price, a better oil beta will help in building a better hedge against oil price moves.

We propose a novel adjustment to the traditional regression beta – we add in short-term sensitivity to news events and oil price shocks

Traditionally, quantitative investors measure the sensitivity of a stock to a macro factor like oil by examining the historical correlation between stock returns and movements in the macro variable. This typically involves some form of correlation analysis or time-series regression using historical data. However, betas computed this way are often criticized as being backwards-looking. In this report we refine the traditional approach by augmenting the regression beta with a short-term component designed to capture a stock's reaction to information events and shocks in the oil price.

Practical tools

To make this research more practical for non-quantitative investors, we have also included two investable baskets – one that we expect to outperform if oil prices rise and another that should do well if oil prices fall. These baskets are available on Bloomberg and can be traded through Deutsche Bank's equity trading desk. We also have a complete list of oil sensitivities for all stocks in the Russell 3000 universe available for clients.

Regards,

Yin, Rocky, Miguel, Javed, and John
Deutsche Bank North American Quantitative Strategy

Stock screens

The two screens below show the stocks from the S&P 500 with the largest positive and negative sensitivity to oil prices. Sensitivity is measured using the Deutsche Bank Composite Oil Beta, which is described in detail in the rest of this report. For a complete list of sensitivities for all U.S. stocks, please contact the Deutsche Bank Equity Quantitative Strategy team at DBEQS.Americas@db.com or 212 250 8983, or speak with your sales representative.

Both these screens are available as custom baskets on Bloomberg, and can be traded through Deutsche Bank's equity trading desk.

Largest positive sensitivity to oil (DBUSOILP)

This screen lists 15 stocks from the S&P 500 universe with the largest positive exposure to oil prices, and is available on Bloomberg with ticker **DBUSOILP**. We expect this basket to outperform if oil prices rise.

Figure 1: Top 15 stocks with largest positive sensitivity to oil price movements, S&P 500 universe (we expect these stocks to outperform if oil prices rise)

Ticker	Name	Deutsche Bank Composite Oil Beta	GICS Industry
HES	HESS CORP	11.9	Oil, Gas & Consumable Fuels
WMB	WILLIAMS COS INC	11.9	Oil, Gas & Consumable Fuels
DNR	DENBURY RESOURCES INC	10.9	Oil, Gas & Consumable Fuels
HOT	STARWOOD HOTELS&RESORTS WRLD	10.9	Hotels, Restaurants & Leisure
FITB	FIFTH THIRD BANCORP	10.7	Commercial Banks
HST	HOST HOTELS & RESORTS INC	10.5	Real Estate Investment Trusts (REITs)
JNS	JANUS CAPITAL GROUP INC	10.4	Capital Markets
ZION	ZIONS BANCORPORATION	10.2	Commercial Banks
IVZ	INVESCO LTD	10.0	Capital Markets
NFX	NEWFIELD EXPLORATION CO	9.7	Oil, Gas & Consumable Fuels
HIG	HARTFORD FINANCIAL SERVICES	9.7	Insurance
VLO	VALERO ENERGY CORP	9.5	Oil, Gas & Consumable Fuels
LUK	LEUCADIA NATIONAL CORP	9.3	Diversified Financial Services
DOV	DOVER CORP	9.3	Machinery
EQT	EQT CORP	9.1	Oil, Gas & Consumable Fuels

Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, S&P, Deutsche Bank

Largest negative sensitivity to oil (DBUSOILN)

This screen lists 15 stocks from the S&P 500 universe with the largest negative exposure to oil prices, and is available on Bloomberg with ticker **DBUSOILN**. We expect this basket to outperform if oil prices fall.

Figure 2: Top 15 stocks with largest negative sensitivity to oil price movements, S&P 500 universe (we expect these stocks to outperform if oil prices fall)

Ticker	Name	Deutsche Bank Composite Oil Beta	GICS Industry
CPB	CAMPBELL SOUP CO	-13.9	Food Products
DUK	DUKE ENERGY CORP	-13.4	Electric Utilities
PG	PROCTER & GAMBLE CO	-13.3	Household Products
ED	CONSOLIDATED EDISON INC	-13.2	Multi-Utilities
SO	SOUTHERN CO	-13.2	Electric Utilities
ABT	ABBOTT LABORATORIES	-13.2	Pharmaceuticals
ARG	AIRGAS INC	-13.1	Chemicals
KMB	KIMBERLY-CLARK CORP	-13.1	Household Products
CLX	CLOROX CO/DE	-12.8	Household Products
PEP	PEPSICO INC	-12.3	Beverages
TGT	TARGET CORP	-12.3	Multiline Retail
K	KELLOGG CO	-12.0	Food Products
MO	ALTRIA GROUP INC	-11.7	Tobacco
AMT	AMERICAN TOWER CORP	-11.7	Wireless Telecommunication Services
AZO	AUTOZONE INC	-11.6	Specialty Retail

Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, S&P, Deutsche Bank

Refining the traditional approach

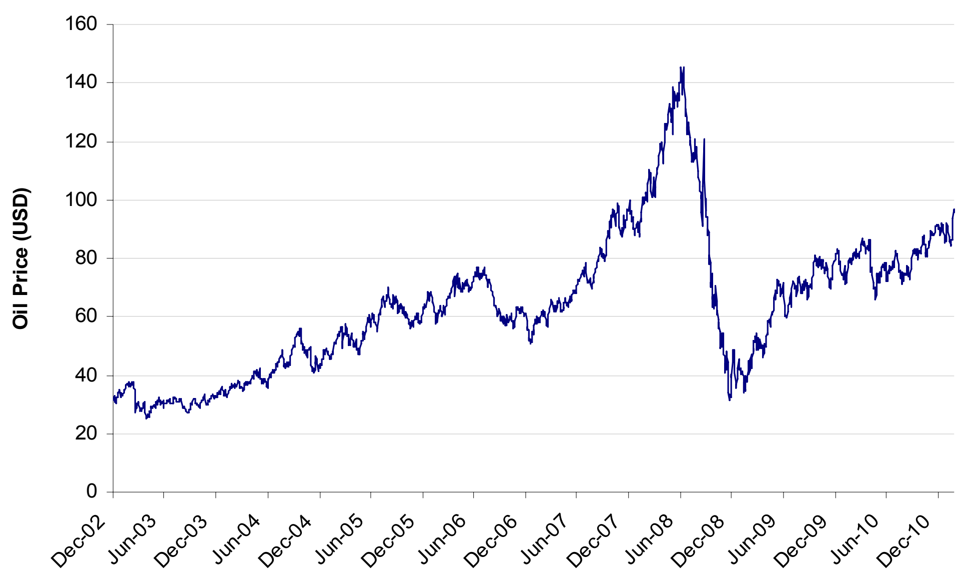
A dangerous world

Macro uncertainty continues to be the dominant driver of stock returns

It goes without saying that the last few weeks in equity markets have been tumultuous. Disasters, both man-made and natural, seem to be popping up almost every trading session. Political unrest is sweeping through vast swathes of the Middle East and Africa, while on the other side of the world the horrific events in Japan have brought one of the world's great economies to its knees.

Aside from the terrible human consequences, the investment implications are – to use the word of the moment – extremely fluid. Nowhere is this more obvious than in the price of oil. As is often the case, this most vital of commodities is once again caught up in the nexus of political and economic uncertainty.

Figure 3: Oil price in USD



Source: Bloomberg Finance LP, Deutsche Bank

But why should quants care?

Traditionally quantitative investors have paid little attention to the macro environment

Quantitative investors have historically been somewhat divorced from the macro environment. From the end of the dot com crash to the start of the financial crisis, benign economic conditions meant that most quant investors were able to focus on building models that played primarily on stock-level characteristics. Over that period, bread and butter strategies like value and momentum performed extremely well. However, since the onset of the financial crisis, the marginal driver of stock returns has largely been big macro themes, and the so called risk on-risk off trade. This in turn has flowed into quant factor performance; in our recent research we found that changes in market-wide risk aversion are having a significant impact on factor returns[1] and factor volatility.[2]

[1] Alvarez, M, Y. Luo, R. Cahan, and J. Jussa, 2010, "Portfolios Under Construction: Volatility = 1/N", *Deutsche Bank Quantitative Strategy*, 16 June 2010

Now quants are starting to incorporate macro drivers into their models

In reaction to this new world, quant investors are increasingly trying to incorporate more top-down, macro information into their models. This brings us back to the oil price. One of the most common questions we get from clients and our sales desk is: "Which stocks are most sensitive to oil prices?" There are a number of ways to answer this question. One is to take a fundamental approach and analyze an individual company's exposure to oil via its use of raw materials, the energy intensity of its production process, the flow on effects from higher fuel costs, hedging strategies, and so on. Another approach is to take a statistical view and look at the co-movement of a company's stock returns with the price of oil. As quants, we tend to leave the former approach to our fundamental analysts and typically tackle the problem using the latter approach.

What's wrong with the traditional regression beta?

Calculating a simple regression beta to the oil prices is easy, but is it robust?

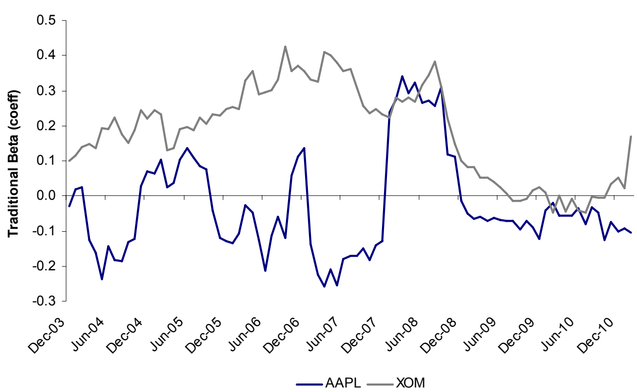
The statistical approach almost invariably involves some kind of time-series regression, where stock returns are regressed on changes in oil price over some trailing period. The details – e.g. the length of the trailing window, the frequency of returns – tend to vary a bit, but broadly speaking the process is well established. After regressing the returns of each stock on changes in oil price, the slope coefficient from the regression is typically taken as the sensitivity, or beta, of that stock to oil. Mathematically, the beta of stock i at time t would be found using the linear regression

$$R_{i,t} = c + \beta_{i,t} R_{oil,t} + \varepsilon_{i,t}$$

where $R_{i,t}$ is the return for stock i at time t, β_i is the beta for stock i at time t, $R_{oil,t}$ is the oil price return at time t, and $\varepsilon_{i,t}$ is the error term.

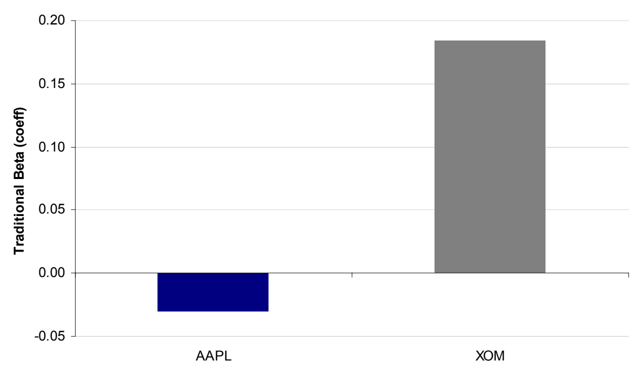
For example, if we use a trailing one year of weekly returns and compute an oil price beta for two stocks – Apple and Exxon Mobile – at each point in time, we get Figure 4.

Figure 4: Traditional regression beta for Apple (AAPL) and Exxon Mobile (XOM)



Source: Compustat, Bloomberg Finance LP, Deutsche Bank

Figure 5: Average regression beta for Apple (AAPL) and Exxon Mobile (XOM), 2003-present



Source: Compustat, Bloomberg Finance LP, Deutsche Bank

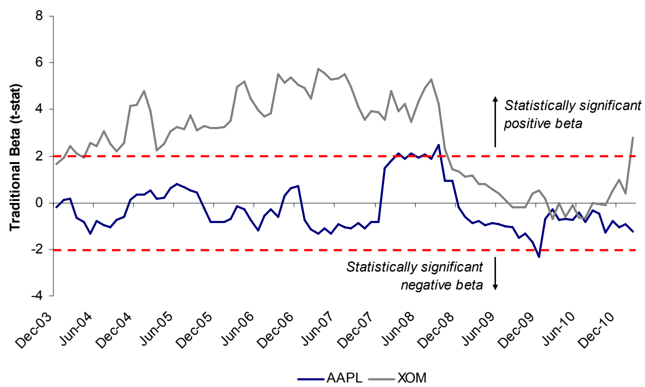
The results are not surprising at all – Exxon Mobile tends to have a positive beta to oil price movements over time, while Apple has an average beta close to zero (Figure 5). However, the simple beta coefficient does not tell the whole story because it is hard to judge the significance of the results – is Exxon's average beta of around 0.18 actually meaningful? Is Apple's beta really different from zero?

[2] Luo, R., R. Cahan, M. Alvarez, J. Jussa, and J. Chen, 2011, "Portfolios Under Construction: Robust factor models", *Deutsche Bank Quantitative Strategy*, 24 January 2011

Using the t-statistic instead of the beta coefficient can be beneficial

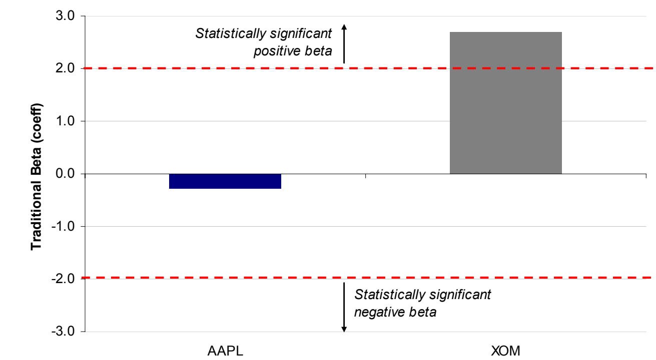
Of course, there is an easy way to get a handle on this. If we look at the t-statistic of the beta for each stock, we can get a sense of how statistically significant each result is. Figure 6 and Figure 7 show the same charts as before, except using the t-statistic instead of the beta coefficient itself. Roughly speaking, a t-statistic greater than +2 or less than -2 indicates the coefficient estimate is statistically significant at the 95% level, so now we can get a better picture of whether the relationship between each stock's returns and oil is statistically different from zero. For Exxon Mobile the answer is yes, for Apple it is no.

Figure 6: T-statistic beta for Apple (AAPL) and Exxon Mobile (XOM)



Source: Compustat, Bloomberg Finance LP, Deutsche Bank

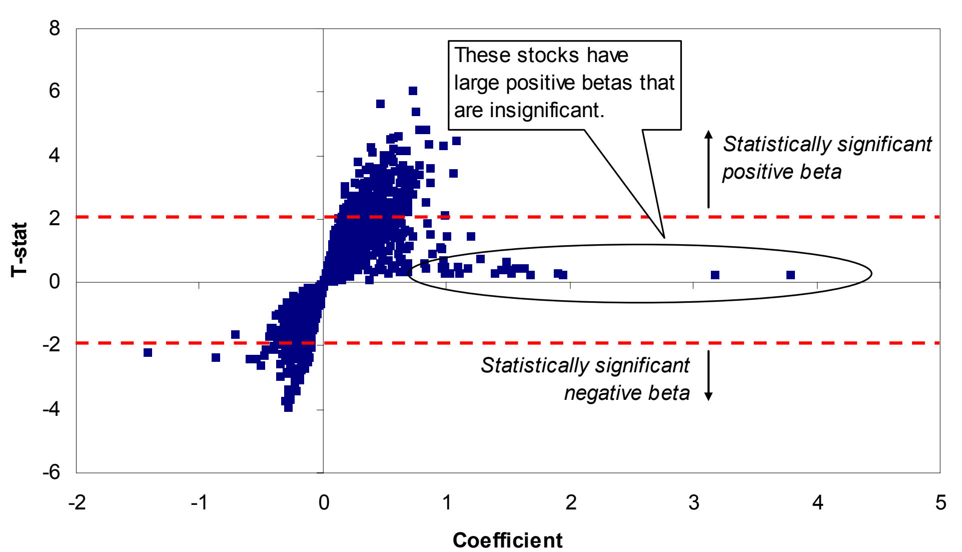
Figure 7: Average t-statistic beta for Apple (AAPL) and Exxon Mobile (XOM), 2003-present



Source: Compustat, Bloomberg Finance LP, Deutsche Bank

So far there is nothing new here, and regular readers of our research could be forgiven for wondering why we have suddenly gone back to our Statistics 101 textbooks.

Figure 8: Scatter plot of t-statistic versus coefficient, as at 28 Feb 2011, Russell 3000



Source: Compustat, Bloomberg Finance LP, Deutsche Bank

The problem with the beta coefficient is that a number of the high betas are statistically insignificant

The reason for our sudden interest in freshman statistics lies in Figure 8. The chart shows a simple scatter plot of t-statistic versus beta coefficient at a single point in time. In other words, we first regress returns for every stock against changes in the oil price, using one year of weekly returns. We then plot the t-statistic of the beta coefficient for each stock against the beta coefficient itself. The important feature of the chart is that the large positive betas for many stocks are actually insignificant from a statistical perspective. This is problematic because if we were to rank stocks based on their traditional regression beta, we would almost certainly pick up some "false positives", i.e. stocks that appear to be highly correlated with oil, but actually aren't once the margin of error in the beta estimate is taken into account.

The implication is clear: instead of using the traditional beta coefficient to measure sensitivity to oil, a better metric is probably the t-statistic of the beta coefficient. The beauty of the t-statistic is that it jointly measures the direction of the sensitivity and the confidence we have in that estimate.

Economic significance is what matters

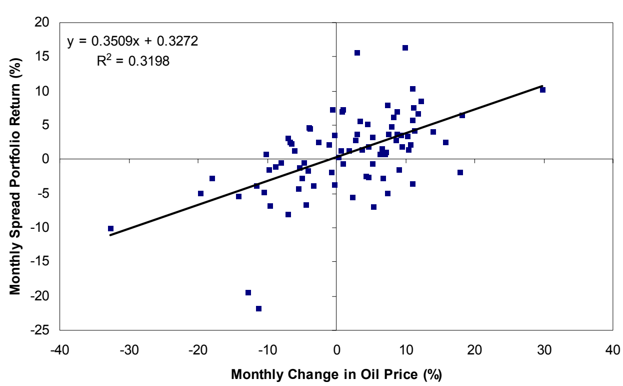
We assess the accuracy of our beta metrics by building long-short beta portfolios and tracking their correlation to future oil price movements

However, investors don't make money out of statistical significance (which is primarily a measure of how well the model explains backwards-looking, in-sample relationships). What we really care about is economic significance. One of the biggest problems with assessing whether a beta is "good" or "bad" is deciding how we should measure this concept. One idea might be to look at how well today's beta predicts tomorrow's return. If a stock has a high beta today, then tomorrow if oil prices go up we would hope that the stock outperforms.

We can translate this same idea to the portfolio level. Suppose we form a simple long-short portfolio that goes long high beta stocks and short low beta stocks each month. If oil prices go up next month then we would hope this portfolio would outperform. If it doesn't, then that would suggest our beta estimates have poor predictive power in the future.

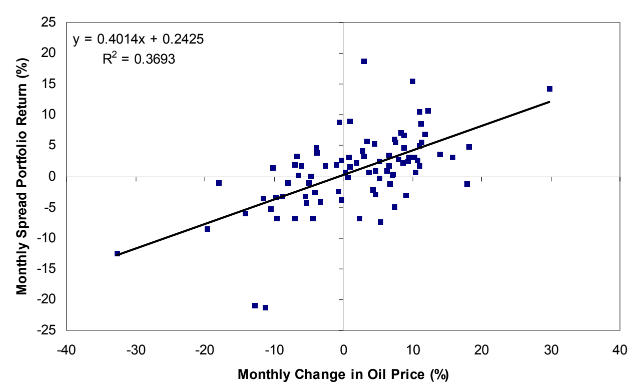
Specifically, at the end of each month we form a simple, equally-weighted portfolio that goes long the 10% of stocks with the highest beta coefficients and short the 10% of stocks with the most negative beta coefficients. Figure 9 shows a scatter plot of the performance of this portfolio in the following month against the change in oil price in the following month.

Figure 9: Coefficient beta: Performance of High Beta—Low Beta portfolio versus monthly change in oil price



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

Figure 10: T-stat beta: Performance of High Beta—Low Beta portfolio versus monthly change in oil price



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

Figure 10 shows the same chart, except this time we form our portfolios based on the t-statistic of the beta coefficient.

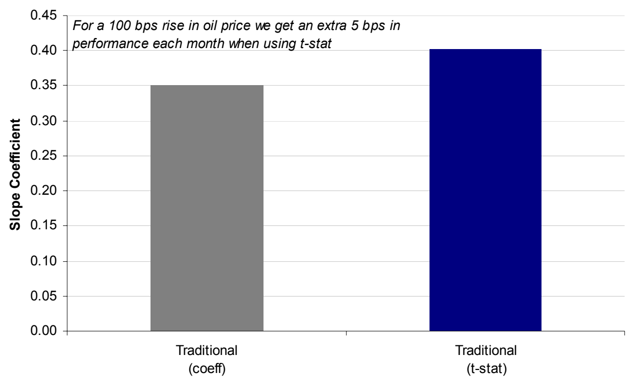
A portfolio built using traditional beta has a strong correlation with future oil prices…

The results are interesting for two reasons. First, if we look at Figure 9 we find that there is a positive relationship between portfolio performance and the oil price. This is good because it suggests that our oil price betas have some predictive power, because if oil prices go up then the portfolio generates positive returns and vice versa. Note that here we are testing the forwarding looking predictive power of the betas, because the portfolios are formed using betas available at time *t*, and then the performance is measured from time *t* to *t*+1, so there is no lookahead bias in the results.

...but we can do even better if we use the t-statistic beta instead

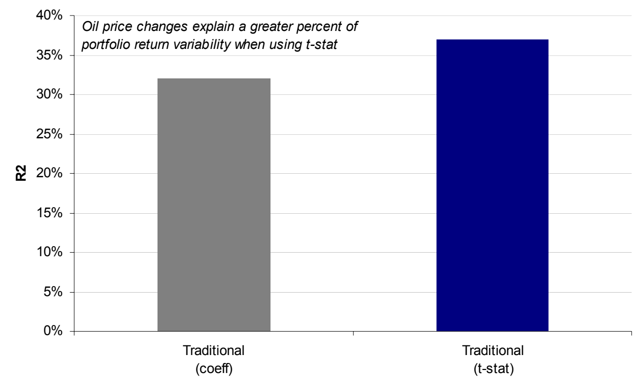
The second interesting finding is that the slope of the regression is more positive when we use the t-statistic as our beta instead of the coefficient itself. Essentially the slope of the regression measures the amount by which portfolio returns increase for a unit increase in the price of oil. The slope using the t-statistic is about 0.4, which indicates that for a 1% increase in the price of oil, we expect monthly portfolio performance to improve by 40 bps. In contrast, for the beta coefficient, the slope is about 0.35, which translates into a 35 bps per month increase in portfolio performance for a 1% rise in oil. As summarized in Figure 11, the difference between the two models is about 5 bps per month for every 1% increase in oil price. When annualized, this can start to add up.

Figure 11: Comparison of slope coefficient using alternative beta measures



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

Figure 12: Comparison of R2 statistics using alternative beta measures



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

We also find that the R-squared when using the t-statistic as the beta is higher than when using the coefficient (Figure 12). This implies that changes in oil price do a better job at explaining variation in portfolio returns when we use the t-statistic as our beta measure.

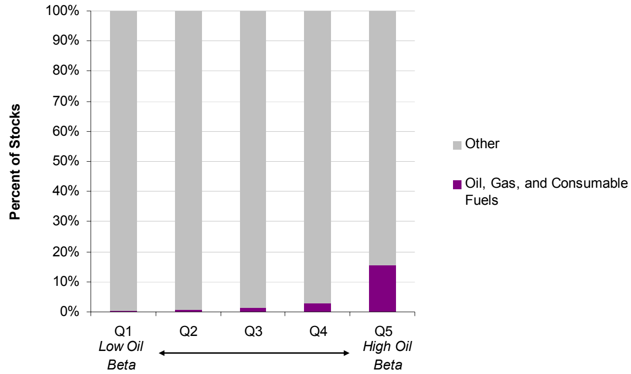
So to summarize our results thus far, our first important finding is that using the t-statistic as the beta metric instead of the coefficient itself improves both the statistical properties (which is of less interest) and the forward predictive power (which is vitally important) of the model. Therefore, in the rest of this paper when we refer to the traditional regression beta, we mean the t-statistic of the regression coefficient, not the coefficient itself.

Should we be sector neutral?

As we would expect, the oil price betas are strongly skewed towards the energy sector

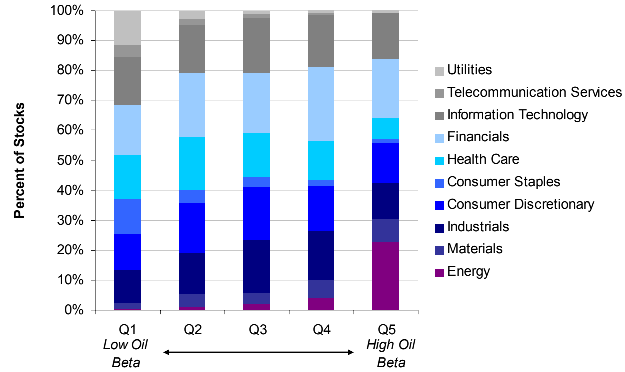
The question of whether we should sector-adjust our betas is an important one. If we choose not to sector-adjusted, then naturally the stocks with large positive betas will tend to be from the oil-related sectors. Figure 13 shows the percent (based on number of stocks) of each beta quintile that come from the GICS Oil, Gas, and Consumable Fuels industry (101020). As expected, stocks from this industry are most prevalent in Quintile 5 (high oil beta stocks). We see a similar picture if we look at the GICS Level 1 Sectors (Figure 14), where Energy stocks are concentrated in Q5.

Figure 13: Percent of stocks in each beta quintile that come from GICS 101020



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, S&P, Deutsche Bank

Figure 14: Percent of stocks in each beta quintile that come from each GICS Level 1 Sector

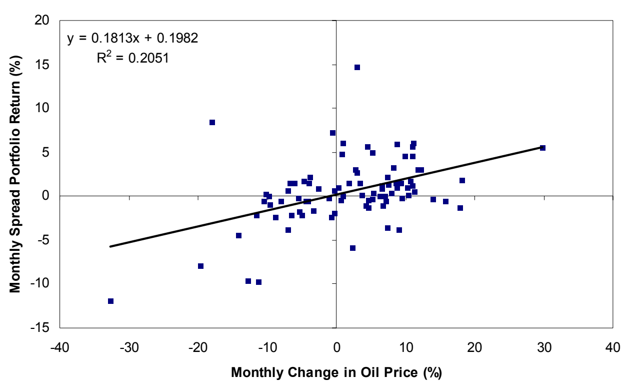


Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, S&P, Deutsche Bank

Using a sector neutral beta leads to a portfolio that is less correlated with future oil price movements

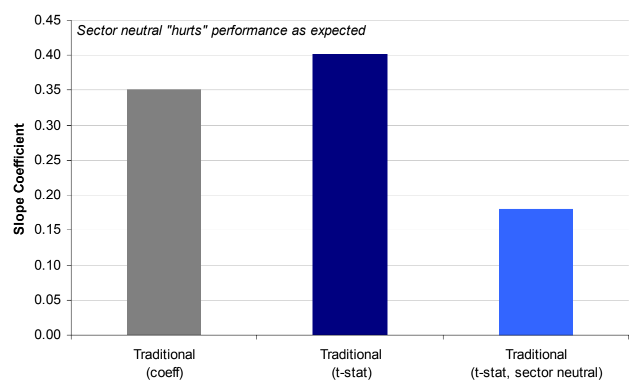
So at the risk of stating the obvious, it is clear that if we form portfolios based purely on beta, without taking sector effects into account, they will have a significant sector bias built in. What happens if we try to control this? One simple way to do this is to do a cross-sectional regression at each point in time, where we regress stock oil betas onto sector dummy variables. The residuals from this regression are the sector-adjusted betas. What happens to our long high beta-short low beta portfolio when we use sector-adjusted beta instead? Figure 15 shows the same scatter plot as before, and Figure 16 compares the slope coefficient from the sector-adjusted beta to the other betas we've considered so far.

Figure 15: Sector neutral t-stat beta: Performance of High Beta—Low Beta portfolio versus monthly change in oil price



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

Figure 16: Comparison of slope coefficient using alternative beta measures



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

As we would expect, once we sector-adjust the betas, the month-ahead correlation between portfolio returns and oil price movements falls significantly. This is because we no longer hold the unconditionally highest and lowest betas in the long and short portfolio respectively; instead we hold stocks with high and low betas relative to their sectors.

For investors who are using the oil beta in an overlay or hedging strategy, sector neutralizing the beta may help

For this reason the question of whether to sector-adjust the oil beta depends largely on the application. If the investor is seeking to build a portfolio that maximizes exposure to future oil price movements, then it makes little sense to try to steer away from the sectors that are most sensitive to oil. However, if the betas are being used more as a hedge or an overlay strategy, then sector-adjusting the oil betas may make sense to avoid introducing a significant sector skew into the portfolio.

Introducing short-term shocks

The power of the news

Statistical betas are always backwards looking, but can we make them timelier?

One of the common criticisms with statistical betas is that they are, almost by definition, backwards looking. The empirical evidence so far suggests that when it comes to oil betas, this criticism is not necessarily justified – we showed how a portfolio constructed using regression betas does tend to co-move with future oil prices reasonably closely. Nonetheless, it is worth exploring whether we can potentially make the betas timelier. One idea is to use a stock's reaction to past oil-related news as a way of measuring the stock's sensitivity to short-term information events.

Our news sentiment database includes oil-related news stories

In our recent research one of the most interesting data sources we have tested is a news sentiment database.[3] The idea is to use computer algorithms (called Natural Language Processing or NLP algorithms) to analyze the text of news stories, with the aim of objectively assessing the story's tone (or sentiment), novelty, and relevance in real-time. Our previous research found that such data can be useful at the stock level for predicting future stock returns, and indeed most research to date has focused on using news sentiment to predict equity returns.[4] However, an interesting feature of the data set that we use – the Thomson Reuters News Analytics database – is that it also includes sentiment data for commodities like crude oil. Figure 17 shows a snapshot of part of the dataset.

Figure 17: Snapshot of select news analytics metrics for Crude Oil

SYMB	ESTTIME	RLVN	SENT	SPOS	SNEU	SNEG	CNT1	BTXT
CRU	02/25/2011 22:28:38	0.58	-1.00	0.42	0.02	0.56	6	UPDATE 1-Clinton's Geneva trip seeks consensus on Libya
CRU	02/26/2011 00:05:15	1.00	-1.00	0.30	0.10	0.61	2	U.S. REFINERY FILING - NATIONAL RESPONSE CENTER - SHELL OIL/CHEMICAL AND REFINERY
CRU	02/26/2011 00:05:17	1.00	-1.00	0.07	0.17	0.76	3	U.S. REFINERY FILING - NATIONAL RESPONSE CENTER - EXXON MOBIL
CRU	02/26/2011 00:15:16	1.00	-1.00	0.10	0.08	0.82	0	IRAQ'S BAIJI OIL REFINERY SHUT DOWN BY BOMBING -- PROVINCIAL GOVERNOR
CRU	02/26/2011 04:10:40	1.00	-1.00	0.18	0.04	0.78	4	UPDATE 3-Militant bombing shuts Iraq's largest oil refinery
CRU	02/26/2011 02:16:40	1.00	-1.00	0.15	0.05	0.80	3	UPDATE 2-Iraq's largest oil refinery shut by bombing
CRU	02/26/2011 00:28:36	1.00	-1.00	0.37	0.08	0.55	1	Iraq's Baiji oil refinery shut by bombing - official
CRU	02/26/2011 00:51:32	1.00	-1.00	0.37	0.06	0.58	2	UPDATE 1-Iraq's largest oil refinery shut by bombing
CRU	02/25/2011 21:50:57	0.87	-1.00	0.17	0.03	0.80	12	WRAPUP 1-US imposes sanctions on Gaddafi, Tripoli the focus
CRU	02/26/2011 00:05:01	1.00	-1.00	0.27	0.12	0.61	0	U.S. REFINERY FILING - NATIONAL RESPONSE CENTER - SHELL OIL

Source: Thomson Reuters, Deutsche Bank

Essentially each row in the database represents a news story. The ESTTIME field indicate the exact time (in EST) that each story was released. The BTXT field contains the headline for each story, which as expected confirms that each story is oil-related. The other important metrics are:

- **Relevance (RLVN):** This is a score from 0 to 1 that measures how specific the story is to oil itself. A RLVN of 1 indicates the story is highly relevant to oil, whereas 0 is low relevance. The relevance is determined purely by the linguistic characteristics of the story, i.e. the vocabulary and grammatical structure.
- **Sentiment (SPOS, SNEU, SNEG):** These three scores measure the probability of positive, neutral, and negative sentiment in the story, as it relates to oil. In other words,

[3] Cahan, R., Y. Luo, J. Jussa, and M. Alvarez, 2010, "Signal processing: Beyond the headlines", *Deutsche Bank Quantitative Strategy*, 19 July 2010

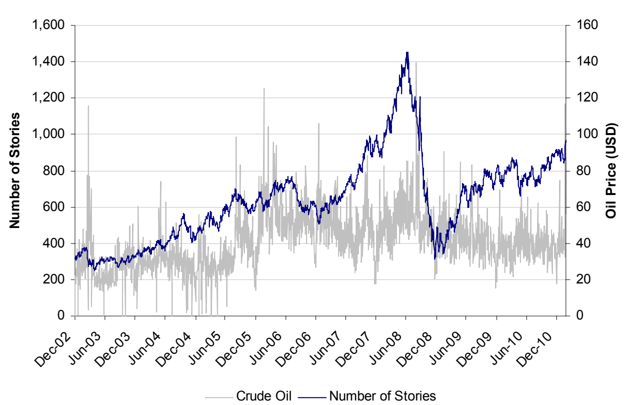
[4] One exception is an interesting paper by Svetlana Borokova, who was a fellow presenter at the recent Thomson Reuters News Sentiment Roundtable in London that we also presented at. Her paper, titled "The impact of news sentiment on energy futures returns", examines how sentiment from news stories about commodities can be useful for forecasting future commodity price movements and also movements in the forward curve. For more details see http://ssrn.com/abstract=1719582.

the NLP algorithms are sophisticated enough to tease out the sentiment that relates specifically to oil, rather than the general sentiment of the story. Note that sentiment for oil is a little different than sentiment for equities, because news that might be considered "bad" in most contexts might actually be "good" for oil. For example, a headline that reads "Massive explosion destroys refinery, hundreds injured, widespread contamination" would in most contexts be considered negative. However, this is likely to be a positive story for oil prices, because it suggests a reduction is supply capacity and hence a potential price rise. For this reason, the NLP algorithms used on oil stories are trained separately from the general algorithms used for other assets.

- **Novelty (CNT1, CNT2, …):** Novelty is measured by looking at how many similar stories have appeared in the past 12 hours, 24 hours, and so on (note that in Figure 17 we only show a subset of the columns that are available in the database). Similarity in the Thomson Reuters News Analytics database is assessed by computing the "linguistic fingerprint" of a story, and then looking back through time to see if there have been any stories with similar fingerprints in the past.

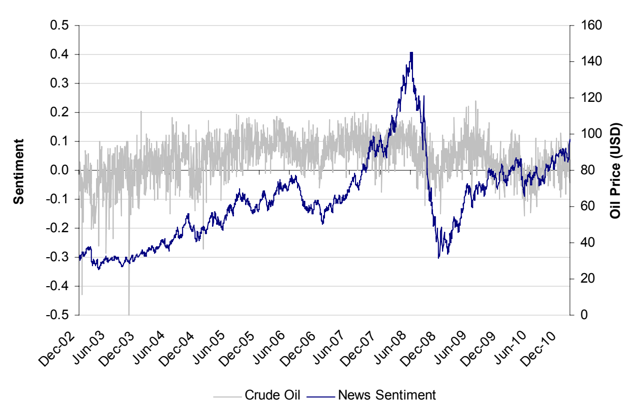
Figure 18 shows the number of news stories per day about crude oil. Given oil is such an important commodity, it is not surprising that on average there are around 400 news stories per day that are at least partially related to oil.

Figure 18: Number of news stories about oil per day



Source: Thomson Reuters, Bloomberg Finance LP, Compustat, Deutsche Bank

Figure 19: Daily news sentiment for stories about oil



Source: Thomson Reuters, Bloomberg Finance LP, Compustat, Deutsche Bank

Because there are so many stories per day, we need a way to aggregate sentiment across all stories on a given day, so that we can have one sentiment reading each day (in this research we do not consider intraday horizons). We do this by computing a relevance-weighted average of net sentiment across all stories about oil each day. Specifically, we compute the oil sentiment on day t as

$$SENT_t = \sum_{k=1}^{K} RLVN_k (SPOS_k - SNEG_k)$$

where $k = 1,\ldots,K$ loops through all news stories about oil on day t. Note that day t is defined as any story from 3.30pm EST on trading day t-1 to 3.30pm EST on day t. The 3.30pm cutoff is to avoid any potential lookahead bias if we form an investment strategy that requires execution at the close on day t.

Building a news sentiment beta

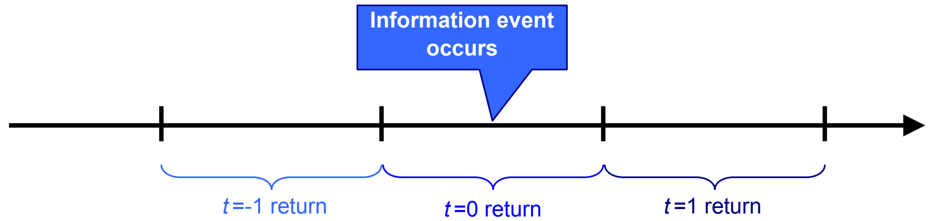
Can we use a stock's reaction to oil-related news to build a timelier beta?

The next step is to use the sentiment to measure "information events". At each point in time, we define a positive (negative) information event as a day where the oil sentiment reading is in the top (bottom) 10% of all days over the past year. Then, on date t for stock i we estimate the following regression

$$R_{i,j,[-1,+1]} = c + \beta_i SENT_j + \varepsilon_i$$

where $R_{i,j,[-1,+1]}$ is the market-adjusted return for stock i in the [-1,+1] day period around information event j (Figure 20), and $SENT_j$ is the oil sentiment reading for the j th information event. Note that the subscript j loops through all information events in the past one year.

Figure 20: Event window for assessing stock reaction to news event



Source: Deutsche Bank

In words, all we are doing is trying to measure how strongly a stock has reacted to extreme sentiment events in the past year. If β_i is high, then a stock tends to have a high abnormal return around positive news days, and low or negative returns around negative news days. If the relationship also holds in the future, then we would expect stocks with a high "news beta", β_i, to react positively in the short-term to positive information shocks, and negative to negative information shocks. In the next section we will test whether this is the case.

Oil price shocks

We can also measure a stock's reaction to sharp jumps or falls in the oil price

One obvious question that arises from our news beta study is whether we could just as easily measure shocks by considering jumps in oil price, instead of news sentiment. We could make the argument that the market is the ultimate judge of sentiment, and a large jump or fall in the price of oil represents a positive or negative sentiment day. To test this we use the same analysis as above, except instead of defining an information event based on sentiment, we define a shock as a day when the change in oil price is in the top or bottom 10% of all daily moves, based on one year of trailing data. We can then modify our regression to

$$R_{i,j,[-1,+1]} = c + \beta_i R_{oil,j} + \varepsilon_i$$

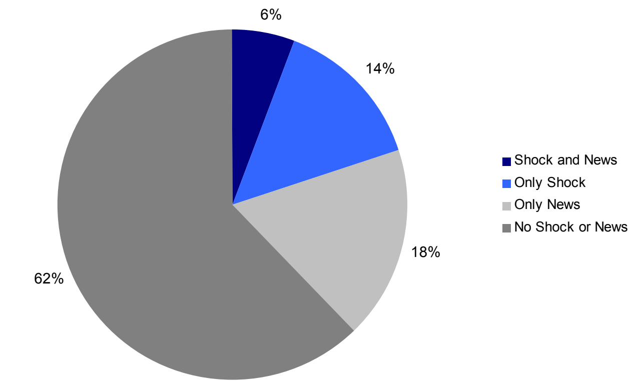
where $R_{i,j,[-1,+1]}$ is the market-adjusted return for stock i in the [-1,+1] day period around shock event j, and $R_{oil,j}$ is the change in oil price associated with the j th shock event. Again, the subscript j loops through all shock events in the past one year. In this formulation, β_i, now measures the short-term response for each stock to past one-day extreme moves in oil price, instead of extreme sentiment days.

It turns out that news events and price shocks are two quite different things

But don't these two betas measure the same thing? Actually, it turns out they are quite different. Figure 21 shows the percent of days that have various combinations of information events and oil price shock events. In fact, these two types of events only occur together on around 6% of days in our backtest period. So it is quite possible, and indeed common, for the oil price to jump without a corresponding spike in sentiment, and vice versa.

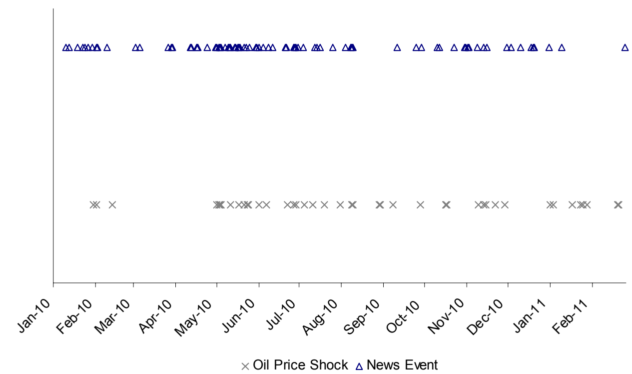
So the next question we need to answer is whether one is better than the other, and further whether either of our short-term betas outperform the more traditional regression beta that we analyzed in the first section.

Figure 21: Percent of days with each possible combination of information event and oil price shock



Source: Thomson Reuters, Bloomberg Finance LP, Deutsche Bank

Figure 22: Time-series of information event days and oil price shock event days, most recent year



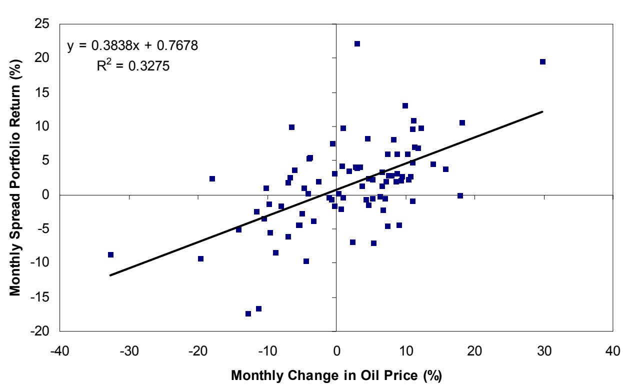
Source: Thomson Reuters, Bloomberg Finance LP, Deutsche Bank

Predictive power of news and shock betas

Both the news beta and price shock beta work well out-of-sample.

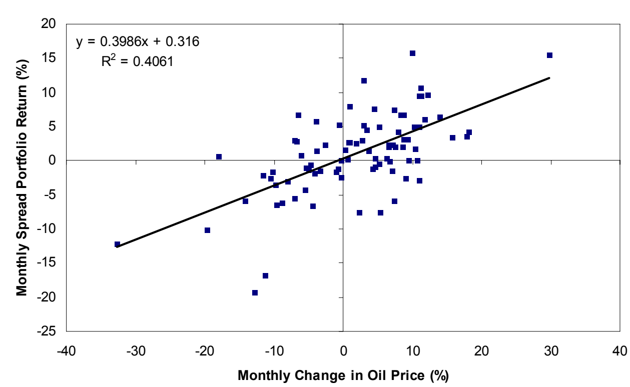
How well do these two short-term beta measures work out-of-sample? In Figure 23 and Figure 24 we conduct the same test we did previous, where we build a high beta-low beta portfolio at the end of each month, and then plot the correlation of the forward returns to that portfolio against forward oil price movements. In both cases the slope coefficient (0.38 and 0.40 for the news and shock betas respectively) is in-line with that for the traditional beta, which was 0.40.[5] Does this imply that all three betas are just measuring the same thing?

Figure 23: News beta: Performance of High Beta—Low Beta portfolio versus monthly change in oil price



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

Figure 24: Shock beta: Performance of High Beta—Low Beta portfolio versus monthly change in oil price



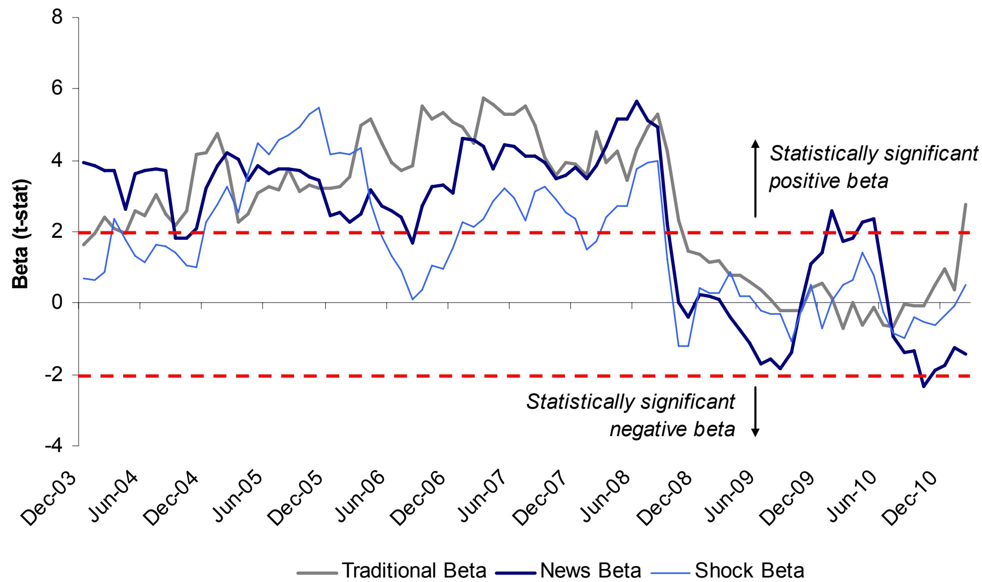
Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

Three alternative betas

To help answer this question, we first consider the correlations between the three alternative betas: traditional regression, news, and oil shocks. Figure 25 shows a single stock example for Exxon Mobile.

[5] To make the comparison fair, we use the t-statistic instead of the beta coefficient for all three beta measures. As shown earlier in this report, the t-statistic is a preferable metric because it considers the confidence we have in the measure in addition to the direction of the sensitivity.

Figure 25: Time-series of alternative beta measures for Exxon Mobile (XOM)



Source: Thomson Reuters, Bloomberg Finance LP, Compustat, Deutsche Bank

In a time-series sense the betas do tend to co-move to a reasonable degree, at least for this single stock. More generally, at each point in time we can compute the cross-sectional correlation between the beta scores for each stock. Figure 26 shows these correlations averaged over time.

Figure 26: Time-series average of cross-sectional correlations

	Traditional Beta	Shock Beta	News Beta
Traditional Beta	1	0.52	0.53
Shock Beta		1	0.65
News Beta			1

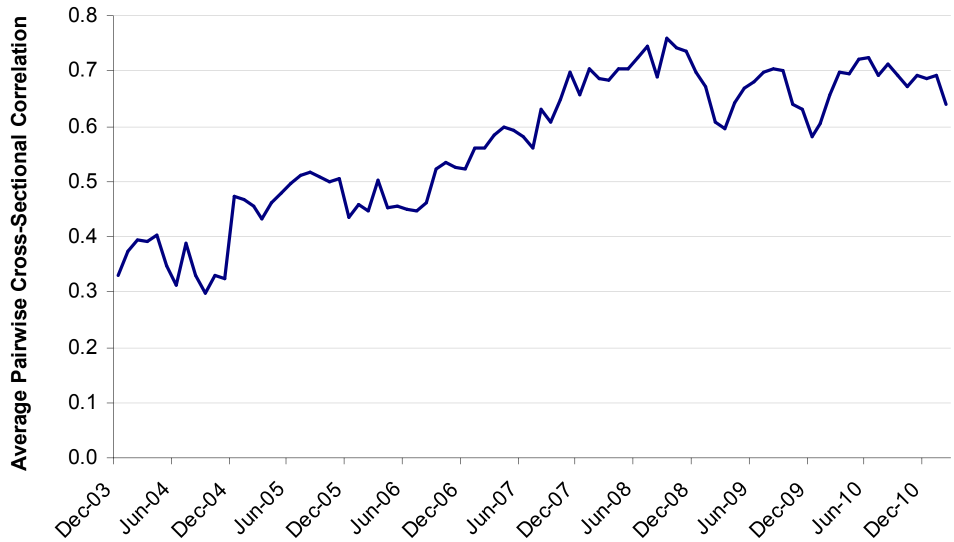
Source: Thomson Reuters, Bloomberg Finance LP, Compustat, Deutsche Bank

The correlation between the three alternative beta metrics is surprisingly low

It turns out the cross-sectional correlations are high, but lower than we expected. This suggests that each beta measure is actually picking up on slightly different aspects or frequencies of oil sensitivity. Particularly noteworthy is the correlation between the oil price shock beta and the news beta, which is 0.65. This confirms our findings previously that news shocks and oil price shocks are not the same thing. This also ties in with our hypothesis that news sentiment is good at capturing qualitative information that is not necessarily priced into the oil price immediately.

Figure 27 shows the average pairwise cross-sectional correlations over time. The overall trend is upwards, so over time the three beta measures have been converging slowly. Nonetheless, the correlation is currently below 70%, so there would still appear to be some diversification benefits available.

Figure 27: Time-series of average pairwise cross-sectional correlation for three alternative beta measures



Source: Thomson Reuters, Bloomberg Finance LP, Compustat, Deutsche Bank

Given the correlation results, a natural extension is to try to construct a composite beta that hopefully captures the information content of each of our three beta metrics. We explore this possibility in the next section.

Building a better beta

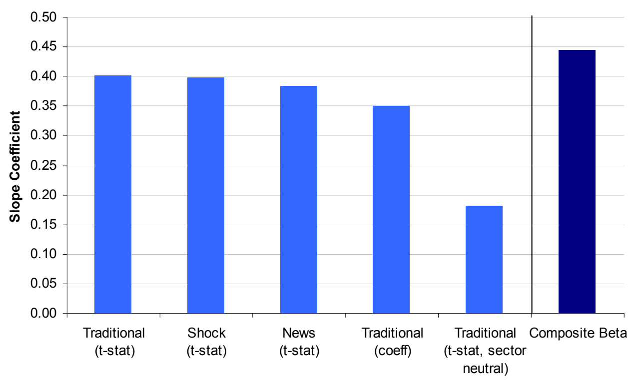
Putting it all together

Three betas is better than one; by combining different types of beta we can boost predictive power

Based on our analysis so far, we found that all three of our proposed betas – traditional regression, news, and oil price shocks – do a good job of predicting the month-ahead oil price sensitivity on a high beta-low beta portfolio. Furthermore, we found that the correlation between each beta is high but not one, which suggests there may be some diversification benefits to be had.

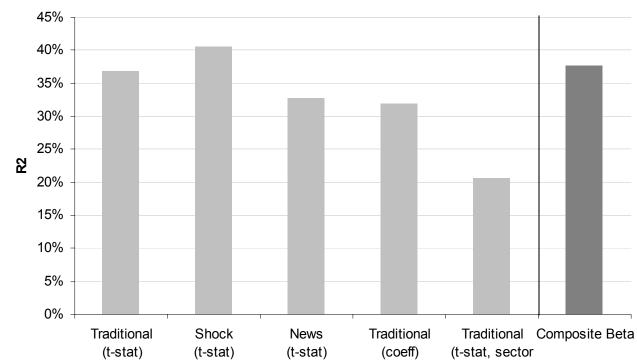
To test this idea we build a simple, equally-weighted composite beta. This beta is constructed by averaging across the three betas for each stock at each point in time. We then conduct the same portfolio tests we did previously, where we use the composite beta to build a long high beta-short low beta portfolio and then track the co-movement of that portfolio with the oil price in the subsequent month. Figure 28 shows that the slope coefficient (which measures the increase in returns to the portfolio for a one unit increase in oil price) is highest for the composite beta compared to all the alternatives. In other words, the resulting portfolio is more sensitive to out-of-sample oil price moves when we use composite beta to build our portfolio. In addition, the explanatory power of oil price moves in explaining portfolio returns is high (although not quite highest) for the portfolio constructed using the composite beta (Figure 29).

Figure 28: Sensitivity of High Beta—Low Beta portfolio versus monthly change in oil price for different beta metrics



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

Figure 29: R2 of High Beta—Low Beta portfolio versus monthly change in oil price for different beta metrics



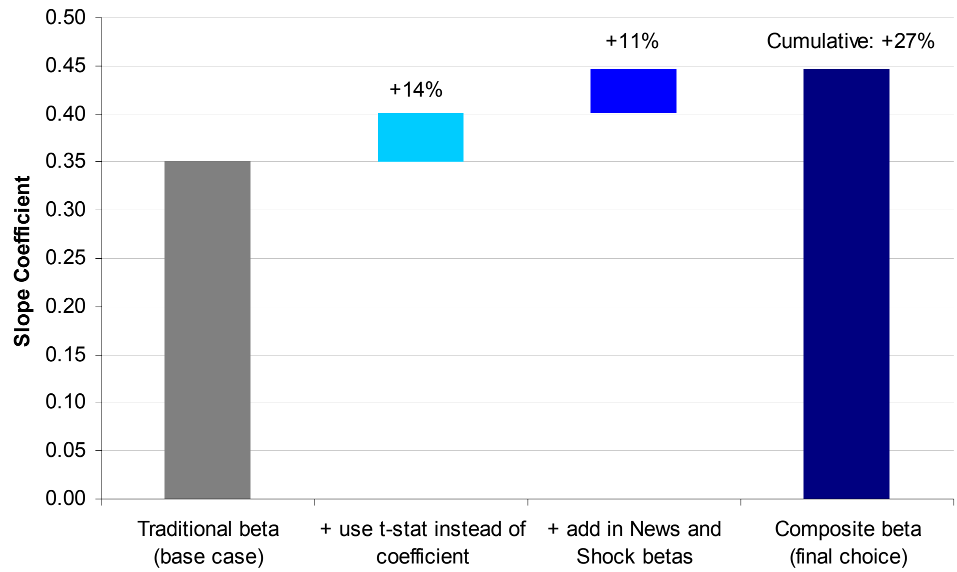
Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

An equally-weighted composite beta does better than any of the individual betas

These results suggest that using the composite beta does yield better out-of-sample performance compared to any of the individual betas. To summarize our findings, Figure 30 shows the cumulative boost in performance (again measured as the slope coefficient when regressing forward high beta-low beta portfolio returns on forward oil price changes) from two distinct enhancements: (1) switching to t-stat instead of the coefficient itself, and (2) adding short-term news and oil price shocks into the mix.

Cumulatively the two enhancements lead to around a 27% improvement over the life of our backtest. This would seem to be a reasonably significant gain.

Figure 30: Cumulative improvement from each beta refinement



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

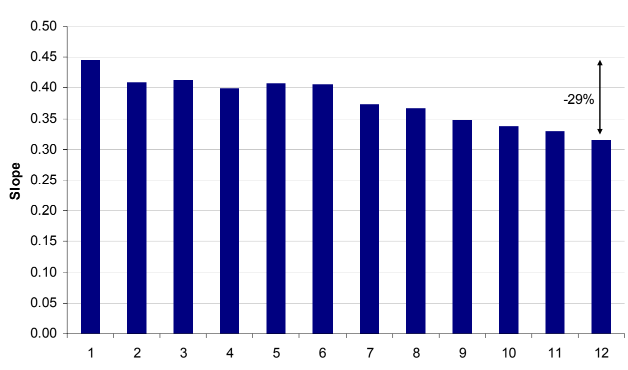
An attractive property of our composite beta is its slow decay rate

How nimble do we need to be in calculating betas?

One final question to address is whether the act of including the short-term betas (news beta and oil price shock beta) in the composite means that the final beta estimates become too unstable. Another way to think about this is to ask how frequently we need to compute the composite beta – can we get away with computing it once a month or do we have to compute it every day?

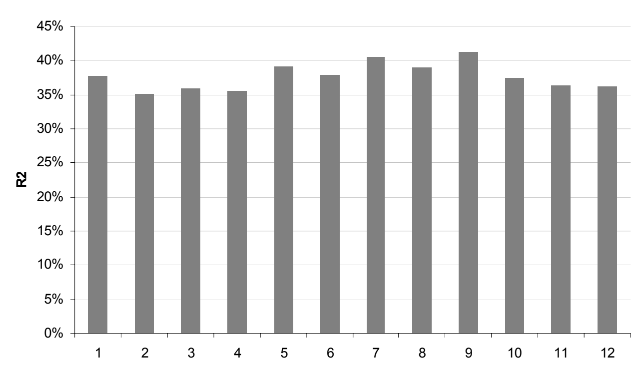
We can analyze this by looking at the "decay" in performance as we apply an increasingly long lag to our beta estimates. For example, if we used the betas calculated, say, six months ago, how would that impact the predictive power of the model. Figure 31 shows how performance changes as we introduce increasingly long lags in the beta estimation. The results are promising in the sense that the decay profile is moderate. Even if we have a 12 month lag on our betas (i.e. use betas that were calculated a year ago), the performance of the model only drops to a level that is still better than what we would get if we used the most up-to-date traditional regression coefficient betas.

Figure 31: Decay in performance by month from beta calculation date



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

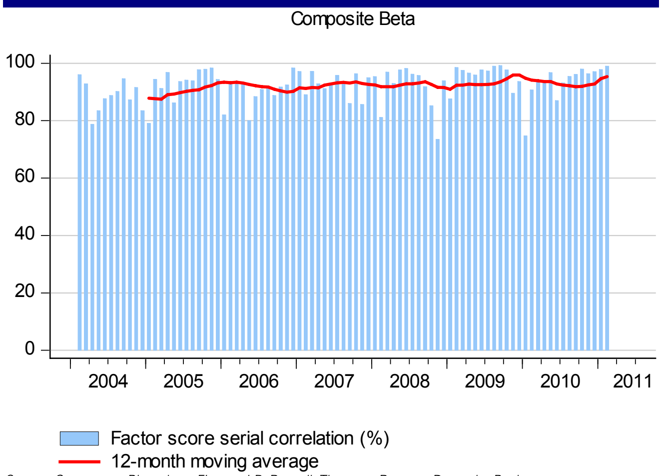
Figure 32: Decay in R2 by month from beta calculation date



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

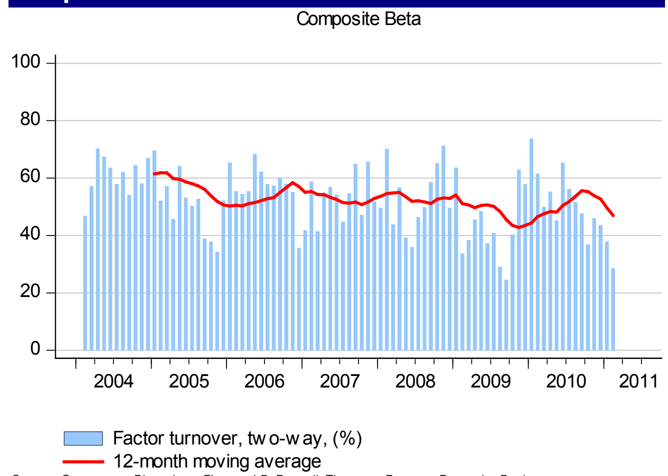
Another way to quantify the decay of the composite beta is to look at the cross-sectional correlation between today's betas and those computed last month (Figure 33). Again we find evidence that the betas don't actually change that much from month-to-month; the autocorrelation is typically between 80-100%. Figure 34 looks at the monthly turnover of a long-short portfolio that goes long the 10% of stocks with the highest composite beta each month and short the 10% with the lowest (most negative) betas. Again, the results suggest that the betas are relatively stable over time.

Figure 33: Cross-sectional autocorrelation of composite beta scores



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

Figure 34: Monthly turnover of portfolio based on composite beta scores



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

Oil beta in the real world

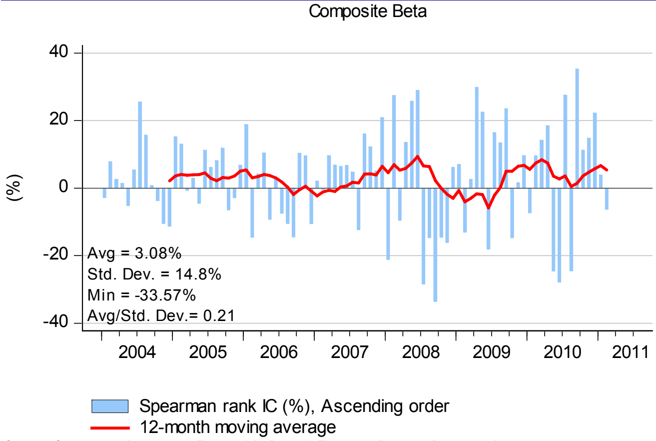
The impact of oil forecasting accuracy

Generating alpha using the oil price beta is conditional on having some ability to forecast the oil price

Up to now we have glossed over one crucial point: all our results so far are premised on the fact that one knows the direction of oil prices in the future. For example, when we test our betas, we do so by looking at how well a long-short portfolio based on those betas performs when oil prices rise and fall in the future. We say a beta is "good" if its portfolio is more correlated with oil in the future. But in the real world, to extract alpha from such a portfolio, we would first have to be right about the future direction of oil, otherwise forming a portfolio that is correlated to oil is of little use.

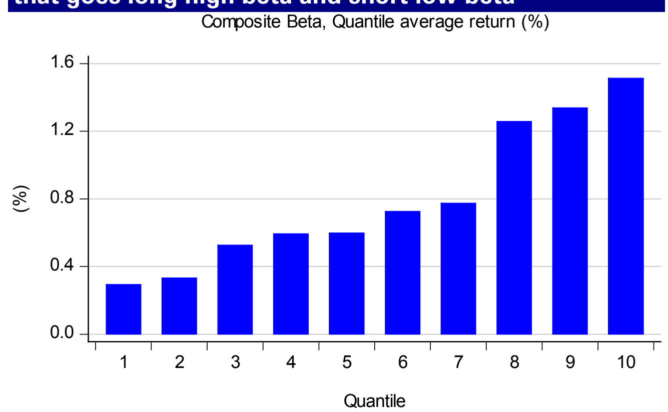
To illustrate this point, supposed we take our composite beta and backtest it as an alpha factor. Figure 35 shows the monthly rank information coefficient (IC) of the backtest and Figure 36 shows the average monthly returns by decile.

Figure 35: Monthly rank information coefficient (IC) for a strategy that goes long high beta and short low beta



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

Figure 36: Average monthly decile returns for a strategy that goes long high beta and short low beta



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

Based on this backtest, the sensitivity of a stock to oil is actually a good stock-selection factor. A 3% average monthly IC is actually a fantastic result for a quant factor in the U.S. market over this period. But before we rush out to set up a hedge fund on the back of these results, a little reflection will quickly reveal that the good performance occurs only because oil prices have risen on average over the backtest period. Indeed, the largest returns to the strategy occurred when oil prices were rising sharply before the financial crisis, and the largest drawdowns occurred as oil plummeted during the financial crisis and ensuing recession.

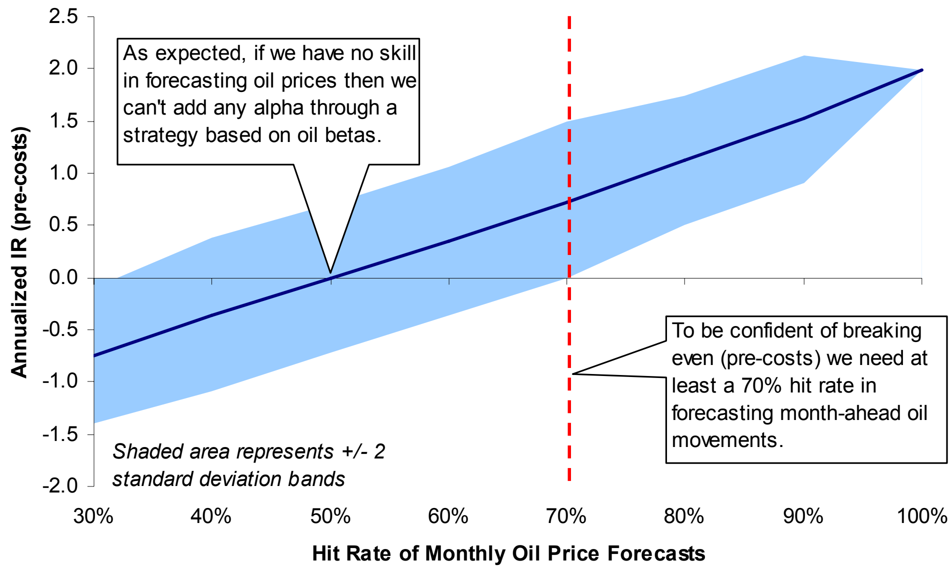
In fact, if we dig a little deeper, we find that oil prices increased in 61% of the months in our backtest period. So we can think of this backtest as representing the performance of our strategy *given we have a 61% hit rate in forecasting month-ahead oil price.*

A simple simulation

How much skill do we need in forecasting the oil price to generate alpha?

So what happens if we generalize this result to consider all possible degrees of accuracy in forecasting oil movements? One way to do this is via a simulation. Suppose each month we try to predict which direction oil will move in the next month. If we think oil will go up, then we would form a portfolio that is long high beta and short low beta stocks. If we think it will go down then we go long the low beta stocks and short the high beta stocks. We then hold the portfolio for a month, and then at the end of the month we repeat the process. If we have no ability to forecast oil prices, then we can simulate this by assuming we have a 50% chance of making the right call on oil each month. Of course, we can also vary this hit rate between 0% and 100%, to get a picture of the relationship between oil forecasting ability and performance. At each level of forecasting ability we can run the simulation many times, to build up a robust picture of the average portfolio performance – and the variability of that performance – at that skill level. Figure 37 shows the results for this simulation.

Figure 37: Breakeven oil price forecast accuracy required to add value through a beta timing strategy, pre-costs



Source: Compustat, Bloomberg Finance LP, Russell, Thomson Reuters, Deutsche Bank

The Y-axis in the chart is the average annualized information ratio (IR) from our stock portfolio over the backtest period. Along the X-axis is our oil price hit rate. The shaded bands show +/- 2 standard deviation bands around the average result. The chart is fairly intuitive. If we are no better than random at picking next month's oil price (i.e. 50% hit rate) then on average we would expect our oil beta strategy to add to value, which is no surprise. The slope of the line indicates that to get a 0.5 increase in portfolio IR, one roughly needs to improve oil price forecasting accuracy by 10%.

To be quite confident of breaking even, one needs around a 70% accuracy in predicting oil price movements

What is more sobering is the breakeven point. If we want to be very sure that our oil beta portfolio will add value, then we need around a 70% hit rate in forecasting month-ahead oil price movements. Needless to say, a hit rate this high is extremely challenging[6]. To make matters worse, this simulation is before transaction costs. In real life, as our timing ability increases (i.e. as we move to the right along the X-axis) then turnover would also increase, because we would have to frequently flip our portfolio 180 degrees (i.e. from long high beta-short low beta to long low beta-short high beta) depending on our oil price outlook.[7] So instead of being a straight line, in real life we would get diminishing marginal improvement in performance from each additional unit of oil price forecasting ability.

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[6] Indeed if one had this skill in forecasting oil prices, then one would probably just trade oil directly via futures rather than trying to implement one's oil call in the equity market.

[7] We explore how to construct such a simulation in more detail in: Cahan, R., Y. Luo, J. Jussa, and M. Alvarez, 2010, "Portfolios Under Construction: It's all in the timing", *Deutsche Bank Quantitative Strategy*, 19 August 2010

However, building portfolios to generate alpha from oil price movements is only one application of the oil beta. For many managers, the betas will be useful for building more accurate hedges, either at a single stock or portfolio level. For example, when building a diversified portfolio, one can try to match the oil beta of the long and short (or underweight) portion of the portfolio. With a more accurate forward-looking beta measurement we should get a better hedge against future oil price movements. This is an interesting area for further study, but given our focus in *Signal Processing* is on the alpha side of the equation, we leave hedging applications to a future research report.

Appendix 1

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