FORECASTING IS HARD
HOW CAN WE BE LESS WRONG?

Tyler Schlosser
April 2017
The following slides represent Tyler’s opinions and do not necessarily reflect the opinions of GLJ Petroleum Consultants.
WHAT PRICE FORECASTING USUALLY FEELS LIKE
A RECENT EXAMPLE

Henry Hub Gas

Dec 31, 2016 futures

GLJ 2017-01 forecast

USD/MMBtu

Date

Mar 30, 2017, 2:32 PM VERDAZO™
What are cognitive biases?

- “Deviations from rationality in judgment”

- Stumbling blocks that prevent you from acting in your own best interest

- Patterns of thinking that will probably make you more wrong
A RECENT EXAMPLE

Henry Hub Gas

Dec 31, 2016 futures

GLJ 2017-01 forecast

Reality
15. Recency.

The tendency to weigh the latest information more heavily than older data. Investors often think the market will always look the way it looks today and make unwise decisions.
BENCHMARK DELIVERY LOCATIONS

- Canadian Light Crude, NGLs
- AECO Gas
- Heavy Crude (WCS)
- WTI Light Crude
- Henry Hub Gas
CURRENT CONDITIONS: FLAT FORWARD CURVES

WTI Crude Oil

$25 spread (backwardation)

$15 spread (contango)

No spread (flat)

Delivery Date
CURRENT CONDITIONS: FLAT FORWARD CURVES

WTI Futures

$25 spread (backwardation)

$15 spread (contango)

Different delivery years

No spread (flat)

Transaction Date

2012  2013  2014  2015  2016  2017

USD/bbl

Proprietary information of GLJ - VERDAZO™
CURRENT CONDITIONS: FLAT FORWARD CURVES

Henry Hub Gas

Delivery Date

Jan 1, 2012

Mar 29, 2017
CURRENT CONDITIONS: FLAT FORWARD CURVES

Henry Hub Futures

Different delivery years

USD/MMBtu

Transaction Date

2012 2013 2014 2015 2016 2017

2012 2013 2014 2015 2016 2017


CURRENT CONDITIONS: FLAT FORWARD CURVES

UK (NBP) Gas Futures

USD/MMBtu

CURRENT CONDITIONS: CANADIAN DISCOUNTS

Edmonton Light Differential to WTI

- 2017 Delivery
- 2018 Delivery
- 2019 Delivery

Graph showing the differential of Edmonton Light crude oil price to WTI from 2015 to 2017.
CURRENT CONDITIONS: CANADIAN DISCOUNTS

WCS Differential to WTI

- 2017 Delivery
- 2018 Delivery
- 2019 Delivery

USD/bbl

2014 2015 2016 2017
THE CAD UPLIFT

WTI Crude in USD and CAD

WTI in CAD:
Same as in early 2007
OIL PRICES VS. US DOLLAR

WTI Price vs Trade-Weighted USD Index (relative to Jan 1997)

Today
FUTURES AREN’T REALLY FORECASTS

- Futures, or forward curves, are not truly spot price forecasts
- In addition to market expectations of future spot prices, other factors influence futures prices

- Interest Rates
- Inflation Expectations
- Storage Costs & Availability
- Insurance
- Asymmetrical Hedging Pressures
- Liquidity
- Speculation
- Rapid Position Unwinding
- Portfolio Effects
HOW GOOD HAVE FUTURES BEEN AT FORECASTING SPOT PRICES?
HOW GOOD HAVE FUTURES BEEN AT FORECASTING SPOT PRICES?
REALIZED 2016 WTI PRICES VS PAST FUTURES FOR 2016 DELIVERY

2016 WTI Prompt vs Historical Futures Value

For example:
(Jan 2016 Prompt Price) minus
(Jan 2011 Futures Contract Price for Jan 2016 Delivery)

2011

2015

Mar 27, 2017, 4:19 PM VERDASOTM

WTI Prompt vs Historical Futures Value (5 yrs ago)

WTI Prompt vs Historical Futures Value (1 yr ago)
Realized WTI Prices vs 1-Year-Ago Futures
REALIZED WTI PRICES SINCE JAN 1, 2012 VS N-YEAR-AGO FUTURES
HOW GOOD HAVE OUR FORECASTS BEEN?

WTI Prompt with Past GLJ Forecasts

USD/bbl


Jan 2016

Jan 2017

Apr 2017
HOW GOOD HAVE OUR FORECASTS BEEN?
HOW GOOD HAVE OUR FORECASTS BEEN?

Henry Hub Gas

8. Conservatism bias.

Where people favor prior evidence over new evidence or information that has emerged. People were slow to accept that the Earth was round because they maintained their earlier understanding that the planet was flat.
QUESTIONS I’VE BEEN ASKED THIS YEAR

• Why should I believe your forecast?
  You probably shouldn’t believe any forecast, including ours

• Why is your forecast better than this other forecast?
  It’s not necessarily better than that other forecast

• Why is your forecast better than just using futures prices?
  It serves a different purpose, but isn’t necessarily better

• Why is your long term forecast much higher than futures prices?
  Our long term forecast responds more slowly to big price changes, and we have a higher long term supply cost view than markets are currently pricing in

• Do you have your own global supply and demand model?
  No, but we look at other models out there (IEA, EIA, NGOs, banks, etc.)
WHAT IS THE GLJ PRICE FORECAST, REALLY?

What it isn’t:

– A crystal ball or ‘trading’ forecast
– Updated every day
– Based on a formula, integrated model or rigid set of principles

What it is:

– Independent
– Relatively stable
– Usually somewhat mean-reverting
– One possible outcome
– Provides a reasonable basis for valuation of oil and gas assets
HOW DO CONSULTANT FORECASTS COMPARE?

WTI Crude Oil

Jan 1, 2017 Forecasts
HOW DO CONSULTANT FORECASTS COMPARE?

3. Bandwagon effect.

The probability of one person adopting a belief increases based on the number of people who hold that belief. This is a powerful form of groupthink and is reason why meetings are often unproductive.
Should the Canadian regulator adopt a single price forecast for reserves evaluations?

Yes, I think so

- Avoid differences between independent evaluators in:
  - asset valuation
  - impairment
  - reserves volumes due to price-driven economic limit variations

- Improve comparability of evaluations for investors and other stakeholders

- Some companies are already doing this anyway
## SEC VS. CONSULTANT PRICE FORECASTS

<table>
<thead>
<tr>
<th>SEC (USA)</th>
<th>CONSULTANT (Canada)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculated: simple average of first days of trailing 12 months</td>
<td>Discretionary</td>
</tr>
<tr>
<td>Constant forever in forecast years</td>
<td>Can change every forecast year</td>
</tr>
<tr>
<td>Wild price swings can occur and affect all forecast years equally</td>
<td>Wild price swings can occur, but usually affect near term more than long term</td>
</tr>
<tr>
<td>No inflation (0%)</td>
<td>Nonzero inflation forecast (usually 2%/year)</td>
</tr>
<tr>
<td>Ignores the future</td>
<td>Contains human judgment about the future, for better or worse</td>
</tr>
<tr>
<td>Ignores current information that isn’t present in historical prices</td>
<td>Builds in current information, for better or worse</td>
</tr>
<tr>
<td>Will definitely be wrong</td>
<td>Will definitely be wrong</td>
</tr>
<tr>
<td>Product</td>
<td>SEC 2014</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>CADUSD</td>
<td>0.9099</td>
</tr>
<tr>
<td>Brent (USD/bbl)</td>
<td>101.30</td>
</tr>
<tr>
<td>WTI (USD/bbl)</td>
<td>95.28</td>
</tr>
<tr>
<td>WCS @ Hardisty (CAD/bbl)</td>
<td>82.63</td>
</tr>
<tr>
<td>Henry Hub (USD/MMBtu)</td>
<td>4.35</td>
</tr>
<tr>
<td>Station 2 (CAD/MMBtu)</td>
<td>4.30</td>
</tr>
<tr>
<td>AECO (CAD/MMBtu)</td>
<td>4.58</td>
</tr>
<tr>
<td>Propane @ Edm (CAD/bbl)</td>
<td>48.89</td>
</tr>
<tr>
<td>Butane @ Edm (CAD/bbl)</td>
<td>70.49</td>
</tr>
<tr>
<td>Condensate @ Edm (CAD/bbl)</td>
<td>103.42</td>
</tr>
</tbody>
</table>
## SEC PRICE FORECASTS: 2016 VS 2015

<table>
<thead>
<tr>
<th>Product</th>
<th>SEC 2015</th>
<th>SEC 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>CADUSD</td>
<td>0.7877</td>
<td>0.7560</td>
</tr>
<tr>
<td>Brent (USD/bbl)</td>
<td>54.06</td>
<td>43.07</td>
</tr>
<tr>
<td>WTI (USD/bbl)</td>
<td>50.16</td>
<td>42.65</td>
</tr>
<tr>
<td>WCS @ Hardisty (CAD/bbl)</td>
<td>46.58</td>
<td>38.02</td>
</tr>
<tr>
<td>Henry Hub (USD/MMBtu)</td>
<td>2.58</td>
<td>2.49</td>
</tr>
<tr>
<td>Station 2 (CAD/MMBtu)</td>
<td>1.80</td>
<td>1.63</td>
</tr>
<tr>
<td>AECO (CAD/MMBtu)</td>
<td>2.68</td>
<td>2.18</td>
</tr>
<tr>
<td>Propane @ Edm (CAD/bbl)</td>
<td>7.03</td>
<td>11.38</td>
</tr>
<tr>
<td>Butane @ Edm (CAD/bbl)</td>
<td>38.21</td>
<td>33.61</td>
</tr>
<tr>
<td>Condensate @ Edm (CAD/bbl)</td>
<td>62.00</td>
<td>55.27</td>
</tr>
</tbody>
</table>
Near Term (0-2 years out)

- Largely informed by futures pricing
- Near-month futures usually most accurate – they contain knowledge of immediate high-probability events (supply draws, pipelines, weather, etc.)
- Can still be wrong by more than 10% by the next day
GLJ FORECAST METHODOLOGY

Long Term (8+ years out)
- Views on long term supply cost and supply/demand balance
- Extremely uncertain
- Defined in real (today’s) dollar terms and then reflected in nominal prices in our forecast
Medium Term (3-7 years out)

- Difficult to predict the exact timing (and direction) of large, sudden price movements
- Smoothly ‘connects’ near and long term forecasts
- Academic research indicates some mean reversion tendency to energy prices in real dollars over the medium and long term

Today 0-2 3-7 8+
CASE STUDY: FORECASTING PROPANE TO OIL PRICE RATIO

End of 2012: 0.33

What will the price ratio be at the end of 2013?
CASE STUDY: FORECASTING PROPANE TO OIL PRICE RATIO

End of 2013: 0.76

What will the price ratio be next month?
CASE STUDY: FORECASTING PROPANE TO OIL PRICE RATIO

Edmonton Propane to Light Oil Price Ratio

Jan 2014: 2.35

Proprietary information of GLJ - Mar 25, 2017, 11:23 AM VERDAZO™
CASE STUDY: FORECASTING PROPANE TO OIL PRICE RATIO

Edmonton Propane to Light Oil Price Ratio

1. Anchoring bias.
People are over-reliant on the first piece of information they hear. In a salary negotiation, whoever makes the first offer establishes a range of reasonable possibilities in each person's mind.

What will the price ratio by year end?
CASE STUDY: FORECASTING PROPANE TO OIL PRICE RATIO

What will the price ratio be in 6 months?

End of 2014: 0.14
CASE STUDY: FORECASTING PROPANE TO OIL PRICE RATIO

Edmonton Propane to Light Oil Price Ratio

Jun 2015: -0.03
CASE STUDY: FORECASTING PROPANE TO OIL PRICE RATIO

Edmonton Propane to Light Oil Price Ratio

Range since 2012: -0.03 to 2.35
WHY ARE OIL PRICES SO HARD TO FORECAST?

- A complex system of systems with many nonlinearities
  - Extraction, supply and processing chains
  - Several international markets
- Geopolitics, fiscal and regulatory policy
- Advancements in technology

Threshold effects
WHY ARE OIL PRICES SO HARD TO FORECAST?

- Low price elasticity
- Financial speculators
- Human psychology and behavioral economics effects
- Oil prices drive and react to news cycles strongly

(gnu’s cycle)
WHY ARE OIL PRICES SO HARD TO FORECAST?

- Low price elasticity
- Financial speculators
- Human psychology and behavioral economics effects
- Oil prices driven by news cycles strongly

13. Placebo effect.

When simply believing that something will have a certain effect on you causes it to have that effect. In medicine, people given fake pills often experience the same physiological effects as people given the real thing.

(gnu’s cycle)
US Oil Ticks Up for 2nd Day on Record OPEC Cut Compliance
Feb 28, 2017, 14:30 EST, CNBC

Oil Prices Slip as Rising US Supplies Offset OPEC Cut Compliance
Feb 28, 2017 17:00 EST, Reuters

Difference in WTI crude price between headline times: $0.15/bbl

Plausible reasons:
USD and market fluctuations, random noise
ASIDE: OIL IS KING IN QUESTIONABLE PRICE MOVEMENT ATTRIBUTION

Our tendency to focus on the most easily recognizable features of a person or concept. When you think about dying, you might worry about being mauled by a lion, as opposed to what is statistically more likely, like dying in a car accident.

17. Selective perception.
Allowing our expectations to influence how we perceive the world. An experiment involving a football game between students from two universities showed that one team saw the opposing team commit more infractions.

Plausible reasons:
USD and market fluctuations, random noise

US Oil Ticks Up for 2nd Day on Record OPEC Cut

Oil Prices Slip as Rising US Supplies Offset OPEC Cut

Difference in WTI crude price between headline times:
$0.15/bbl
POSITIVE FEEDBACK MECHANISMS LEAD TO BIG PRICE SWINGS

While negative feedback mechanisms exist in oil prices, they are longer term in nature.

- Capital Budgets
- Financing
- Fuel Switching, Use and Conservation

Nearly all short term feedback mechanisms are positive, leading to overshooting and extreme prices.

- Revenue Needs of Producers Rise
- Royalties and Taxes Drop
- Service, Labour and Materials Costs Drop
RANKING UNCERTAINTY

Components of a Half-Cycle Economic Analysis

Prices
- Market prices are hard to predict
- Normally predictable to ±70% with 95% confidence one year out
- Hedging can improve certainty

Production & EUR
- Well performance
- Operational issues
- Economic factors can limit

Capital Costs
- Usually predictable within 15%
- Uncertainty largely tied to success/failure and experimentation

Operating Costs
- Transportation bottlenecks
- Line pressures
- Unexpected issues, maintenance
- Competition, partnerships

Royalties
- Long term uncertainty in regulatory framework
- Short term is usually quite certain
Components of a Half-Cycle Economic Analysis

2. Availability heuristic.

People overestimate the importance of information that is available to them. A person might argue that smoking is not unhealthy because they know someone who lived to 100 and smoked three packs a day.

- Market prices are hard to predict
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- Hedging can improve certainty

- Well performance
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- Long term uncertainty in regulatory framework
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HOW UNCERTAIN ARE OIL PRICES?

WTI with 2-Sigma Volatility Bounds

95% confidence
HOW UNCERTAIN ARE OIL PRICES?

June 2014
95% confidence interval for December 2015 WTI price:
$65/bbl to $130/bbl

(it was $37.33/bbl)
HOW UNCERTAIN ARE OIL PRICES?

95% confidence interval for December 2015 WTI price: $65/bbl to $130/bbl (it was $37.33/bbl)

Hindsight Bias

“I knew oil prices would crash when they did.”

(No, you probably didn’t.)

12. Overconfidence.

Some of us are too confident about our abilities, and this causes us to take greater risks in our daily lives. Experts are more prone to this bias than laypeople, since they are more convinced that they are right.
HOW UNCERTAIN ARE GAS PRICES?

1.50 to 6.50 USD/MMBtu

95% confidence
MARKETS CAN ANSWER THESE TYPES OF QUESTIONS

Asked on May 3, 2016:

1. What is the chance that WTI will average at least 60 USD/bbl in 2017?
   
   27%
   
   (So far it’s averaged 52 USD/bbl)

2. What average 2017 WTI price are markets 90% confident will be exceeded?
   
   29 USD/bbl
   
   (Prices would need to average 21 USD/bbl for the rest of 2017 – we’re safe...I think)
STOCHASTIC PRICE FORECASTING: THE ORNSTEIN-UHLENBECK PROCESS

A modified random walk with a mean reversion tendency

Has four parameters:
- $X_0$: initial price
- $\mu$: equilibrium price
- $\sigma$: volatility
- $\theta$: rate of shock dissipation

Ornstein-Uhlenbeck

$$dX_t = \theta(\mu - X_t)dt + \sigma dW_t$$

POSSIBLE PRICE REALIZATIONS

WTI Crude Oil

Possible future price realizations

USD/bbl


Proprietary information of GLJ - Mar 30, 2017, 1:49 PM VERDAZO™
EXAMPLE DISTRIBUTION OF NPV OUTCOMES FOR A SINGLE VIKING WELL

Mean: $539k
P90: -$467k
P50: $140k
P10: $1908k
HOW CAN WE BE LESS WRONG?

• Be aware of our cognitive biases
• Know the limits of how right we can be
  – Don’t try to be ‘right’
• Focus on dealing with not being able to predict prices or project outcomes
  – Build uncertainty into budget/plans/expectations
• Think critically and probabilistically
• Be curious
HOW CAN WE BE LESS WRONG?

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• Be curious


Failing to recognize your own cognitive biases is a bias in itself. People notice cognitive and motivational biases much more in others than in themselves.
“THINK OF FORECASTERS LIKE CIRCUS CLOWNS...”

Just keep a safe distance, and enjoy the show.

—Carl Richards, New York Times
THANKS TO:

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