Tight Oil Money Return on Investment
Eagle Ford Shale Case History

Art Berman
Labyrinth Consulting Services, Inc.

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The Eagle Ford Shale Play

- Located in South Texas between San Antonio and Corpus Christi.
- Horizontal drilling and hydraulic fracturing began in 2008.
- Approximately 17,000 producing wells.
- February production was 935,000 bo/d, down from 1,324,000 in December 2014.
- 71 active horizontal rigs.
- An over-saturated solution gas drive mechanism with a minor structural component.
- Production is volatile oil and condensate.
- 88% of the oil is > 40 API gravity and 32% is > 50 API gravity.
Top 6 Eagle Ford operators were evaluated: Chesapeake, ConocoPhillips, Devon, EOG, Marathon, & Sanchez.

Standard rate vs time decline-curve analysis was used to match production and determine EUR (estimated ultimate recovery).

Production was normalized and vintaged by year of first production.

Group decline-curve analysis by operator & vintaged year of first production from 2013-2016.

Matches were good to excellent for most operators and vintage-year groups.

2017 was problematic as expected because of short production history.

Standard semi-log plots were used in conjunction with log-log plots to calibrate b-exponents for hyperbolic decline.

Oil and gas streams were declined separately and later integrated through BOE (barrel of oil equivalent) conversion.
Integrating Oil, Natural Gas & Natural Gas Liquids (NGL) Production

<table>
<thead>
<tr>
<th>WELLHEAD</th>
<th>OIL PRICE</th>
<th>GAS PRICE</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$60.00</td>
<td>$2.75</td>
<td>NGL value is 42% of $60/bbl</td>
</tr>
<tr>
<td>NGL Yield 80 BPM</td>
<td>0.08</td>
<td>$2.02</td>
<td>$2.75/mcf natural gas price</td>
</tr>
<tr>
<td>Gas Shrinkage 86%</td>
<td>0.86</td>
<td>$2.37</td>
<td>NGL/mcf + Shrunk Gas/mcf</td>
</tr>
<tr>
<td>Market Value of Gas/mcf</td>
<td></td>
<td>$4.38</td>
<td>$600.00/$60/bbl</td>
</tr>
<tr>
<td>Market Value of Condensate</td>
<td></td>
<td></td>
<td>14 Mcf/BOE</td>
</tr>
<tr>
<td>Gas-to-BOE Conversion Factor</td>
<td>14</td>
<td></td>
<td>$60 oil price/$4.29 NGL-adjusted gas price</td>
</tr>
</tbody>
</table>

**PRICE-BASED RATIOS**

<table>
<thead>
<tr>
<th>OIL</th>
<th>NGL</th>
<th>NATURAL GAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$48.69</td>
<td>$20.52</td>
<td>$3.10</td>
</tr>
<tr>
<td>15.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.42</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Labyrinth Consulting Services, Inc.

- The standard conversion of natural gas-to-barrels of oil equivalent is 6:1 based on energy content.
- A value relationship of oil & gas is more useful for economic analysis:
  - $60 (oil spot)/$2.75 (gas spot) = 22.
- NGL (natural gas liquids) production is not reported to the Texas Railroad Commission but annual data is available in 10-K annual filings for companies that are pure Eagle Ford players.
- An average value of 80 barrels per million cubic feet of gas was used:
  - 80 BPM at 42% of oil value.
  - 0.08 x (0.42*$60) = $2.02 uplift/mcf gas.
- Gas shrinkage of 86%: $2.75 * 0.86 = $2.37/mcf.
- NGL + Gas: $2.02 + $2.37 = $4.38/mcf.
- BOE conversion: $60/$4.38 = 14 mcf/BOE.
- Eagle Ford wellhead price is ~$2.20 less than WTI.
- Sanchez’s—the only pure Eagle Ford player evaluated—2017 realized price was $48.60 & 2017 average WTI spot price was $50.88.
Applying EUR to All Wells

- EUR from decline-curve analysis was correlated with 12-month cumulative production.
- The resulting conversion of 2.36 * 12-month cumulative was applied to all wells with at least 12 months of production.
- The resulting EUR map revealed 2 core areas in the northeastern and southwestern parts of the play.
- Contours were color-coded to 25% IRR at $55 wellhead prices (375,000 boe EUR).
- Number of acres and producing wells inside 375 kboe contours were determined.
- The northeastern core area is mostly volatile oil and is developed on ~110 acre/well density.
- The southwestern area is mostly condensate and is developed on ~175 acre/well density.
Eagle Ford Variable Operating Expenses

<table>
<thead>
<tr>
<th>Operating Expenses $/BOE</th>
<th>SANCHEZ</th>
<th>EOG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Expenses (Lifting)</td>
<td>$9.52</td>
<td>$8.70</td>
</tr>
<tr>
<td>Production &amp; Ad Valorem Taxes</td>
<td>$1.43</td>
<td>$2.45</td>
</tr>
<tr>
<td>General &amp; Administrative Costs</td>
<td>$5.63</td>
<td>$1.95</td>
</tr>
<tr>
<td>Interest Expense</td>
<td>$1.35</td>
<td>$1.23</td>
</tr>
<tr>
<td>Exploration Expense</td>
<td>$0.22</td>
<td>$0.65</td>
</tr>
<tr>
<td><strong>Sub Total</strong></td>
<td><strong>$18.15</strong></td>
<td><strong>$14.98</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$14.47</strong></td>
<td><strong>$14.98</strong></td>
</tr>
</tbody>
</table>

- Production expenses—lifting costs—are ~$9/boe.
- Variable operating expenses were ~$14.75 per barrel of oil equivalent in 2017 based on EOG & Sanchez.
- Our long-term standard “plug” number has been $12/BOE but the shift to development & maintenance mode in the Eagle Ford has increased costs.
- $13 variable OPEX used for economics (optimistic).
- Interest expense because of high debt load was a significant cost for most companies.
- $5.5 mm drilling and completion costs.
### Eagle Ford EUR and Economic Results

<table>
<thead>
<tr>
<th>Year</th>
<th>CHK</th>
<th>COP</th>
<th>DVN</th>
<th>EOG</th>
<th>MRO</th>
<th>SN</th>
<th>WTD AVG</th>
<th>BREAK-EVEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>351,823</td>
<td>334,794</td>
<td>348,929</td>
<td>346,365</td>
<td>318,473</td>
<td>193,294</td>
<td>308,288</td>
<td>$49.18</td>
</tr>
<tr>
<td>2014</td>
<td>292,364</td>
<td>393,747</td>
<td>449,498</td>
<td>437,943</td>
<td>369,765</td>
<td>298,145</td>
<td>369,228</td>
<td>$41.05</td>
</tr>
<tr>
<td>2015</td>
<td>257,522</td>
<td>367,310</td>
<td>346,113</td>
<td>375,925</td>
<td>250,617</td>
<td>291,812</td>
<td>313,826</td>
<td>$48.24</td>
</tr>
<tr>
<td>2016</td>
<td>416,386</td>
<td>455,155</td>
<td>352,068</td>
<td>378,690</td>
<td>190,287</td>
<td>191,983</td>
<td>319,643</td>
<td>$47.34</td>
</tr>
<tr>
<td>2017 EUR</td>
<td>317,709</td>
<td>377,452</td>
<td>378,125</td>
<td>388,882</td>
<td>298,989</td>
<td>250,666</td>
<td>299,263</td>
<td>$50.66</td>
</tr>
</tbody>
</table>

- **2014** was the best year for Eagle Ford EUR: weighted average of top companies was 300 kboe.
- **2013 and 2015** were the worst years evaluated.
- **2016** was slightly better than 2015.
- **2017 EUR** includes considerable uncertainty because of short production history but the weighted average was slightly lower than 2016.
- The weighted average EUR for all companies—all years is ~300 kboe with an associated $50.66/barrel wellhead or about $53 WTI price.
- At $55 wellhead price (~$57.50 WTI) most companies had positive NVP 8 and IRR > 10%.
- The Eagle Ford play is marginally profitable overall at projected 2018 WTI prices in the mid-$50 range.
- EOG, Devon and ConocoPhillips have attractive NPV and IRR at those prices.
- Using $50 as a baseline, approximately 1.1 billion barrels of oil were produced at a loss in 2015 & 2016—about 45% of cumulative Eagle Ford production since 2008 of 2.4 billion barrels equivalent.
Economics Are Optimistic For 2013 & 2014 Eagle Ford

- Drilling and completion costs before about mid-2015 were considerably higher: $7-9 mm per well.
- Economics are optimistic for these wells because $5.5 mm was used in all economics.
- Popular perception is that lower well costs are primarily because of improved technology and operator efficiency.
- In fact, about 90% of cost savings are because of price deflation after the oil-price collapse in 2014.
- Most well performance improvements are because of better completion methods.
- Data suggests, however, that much of this is rate acceleration and not reserve addition.
Where Are the Profits?

- Most tight oil companies lost money in 2017 based on full-year 10-K filings.
- Capital expenditures were greater than cash from operations for 73% of evaluated companies.
- Risky to unacceptably high debt levels characterize 77% of tight oil companies.
- Companies have been claiming profitability at prices below 2017 average levels ($51 WTI) since 2016.
- This study suggests that was not generally true in the Eagle Ford Shale play.
- Corporate financial filings confirm the economics from this study.
- Tight oil remains a marginal business after 10 years of production.
Initial High Production Rates Can Be Deceptive

- Cumulative production comparisons indicate that well performance in recent years is poorer than in previous years.
- 2017 wells for EOG and ConocoPhillips had high initial production rates but steeper decline rates than 2016 wells.
- 2017 wells for these companies are likely to have lower EURs than 2016 wells as a result.
- EOG 2016 wells appear to be crossing 2015 trends and may have lower EURs than in that year also.
- Sanchez 2017 and 2016 wells appear to be much worse than wells in most previous years.
- These comparisons represent averages but suggest that claims of performance improvements may be premature.
Implications for Future Production

- EUR analysis and cumulative production comparisons suggest that much of the Eagle Ford is probably at or beyond optimum development.
- High EURs for Eagle Ford suggest large drainage areas.
- Current well spacing of 100 acres probably exceeds optimum infill.
- Poorer late-year well performance may be due to well interference.
- Operators talk about the potential of developing additional zones.
- This is always a possibility but it seems reasonable that these other levels are already contacted by exiting frack vertical dimensions.
- This study confirms the attractiveness of the Eagle Ford play but suggests that its best days may be in the past.
This study shows that Eagle Ford wells for top operators average 300 kboe but many operators claim EURs that are considerably higher.

Part of the disparity is explained by BOE conversion factors: a barrel of NGLs is counted the same as a barrel of oil even though its energy content and value are less than half of a barrel of crude oil.

A 6:1 natural gas to boe conversion accurately reflects energy content but not value.

Sanchez shows how it arrives at 877 boe for an average Comanche Area well.

Using the value-based approach, the average Sanchez Comanche well is 572 boe—a difference of 35%.

877 boe also represents a “3-Stream EUR” consisting of multiple zone completion in upper & lower Eagle Ford & Austin Chalk. This is somewhat misleading and represents “possible” not proven reserves.

It is unclear how representative “Comanche Area 3” is of Sanchez’s average wells.
Implications for Future Oil Prices

- Oil prices have been stagnant for several weeks after reaching $66 WTI in early February.
- Prices are above $65 today but oil traders are bearish about the direction of prices in 2018.
- IEA and EIA have warned about the explosion of tight oil production and U.S. supply is above 1970 record high levels.
- The rig count has doubled at mostly sub-$50 prices and the number of drilled, uncompleted wells continues to grow.
- It is likely that the market has re-priced oil downward because there is adequate to more-than-adequate supply for the near term.
- $65+/- may represent the high mark for the unfolding next price cycle and the possibility of downside is at least as high as higher prices.
• Tight oil plays have added a decade of additional supply to the U.S.
• Reserves are not large (15 billion barrels) by global standards especially considering the ~90,000 current wells needed to produce 5 mmb/d.
• Tight oil is more expensive than conventional plays because horizontal drilling and hydraulic fracturing is costly (despite lower prices).
• The present price of WTI is 2.5 times higher than average prices 1986-2004 in constant 2017 dollars.
• Technology does not create energy. It permits extraction of known resources at higher rates.
• Tight oil economics are marginal to date although current prices should make most plays profitable.
• Over-production was the main factor in the oil-price collapse in 2014. Resurgent over-production is likely to depress prices again.
• Tight oil volumes have surprised many analysts.
• Future supply is solely dependent on capital markets.