Forecastability of petroleum investments on the NCS

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Introduction

- The oil and gas industry is essential to the Norwegian economy.

Figure: Revised national budget for 2017
The oil and gas industry is essential to the Norwegian economy. The ability to forecast future investment in the oil and gas industry is useful for the Norwegian government and the service & supply industry.

Figure: Revised national budget for 2017
The oil and gas industry is essential to the Norwegian economy. The ability to forecast future investment in the oil and gas industry is useful for the Norwegian government and the service & supply industry. The Norwegian national budget provides a one-year ahead forecast of aggregate oil and gas investments.

Figure: Revised national budget for 2017
Introduction

Research questions

- Is investment growth in the oil & gas industry on the NCS forecastable?
Research questions

▶ Is investment growth in the oil & gas industry on the NCS forecastable?
▶ How accurate is the national budget forecast? Is it able to outperform predicting:
  1. no change in investments
  2. no change in investment growth
Introduction

Research questions

▶ Is investment growth in the oil & gas industry on the NCS forecastable?
▶ How accurate is the national budget forecast? Is it able to outperform predicting:
  1. no change in investments
  2. no change in investment growth
▶ Can a parsimonious ADL model outperform the national budget forecast?
Provided in the national budget since 1996.
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Bottom-up-approach based on budgets provided by the oil and gas companies through the plan for development and operations (PDO).
Norwegian national budget forecast of oil and gas investments on the NCS

- Provided in the national budget since 1996.
- Bottom-up-approach based on budgets provided by the oil and gas companies through the plan for development and operations (PDO).
- Contributors:
  - Norwegian Petroleum Directorate (NPD)
  - Statistics Norway
  - Ministry of Petroleum and Energy
  - Ministry of Finance
All data was provided by the Norwegian Petroleum Directorate.

**Figure**: Project process in oil & gas industry

- Exploration
- Appraisal
- Development
- Production
- Decommission

Plan for Development and Operations
All data was provided by the Norwegian Petroleum Directorate.

Dataset consist of 1788 panel data observations from 109 petroleum fields on the NCS between 1970 and 2015.

Figure: Project process in oil & gas industry

- Exploration
- Appraisal
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- Production
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Plan for Development and Operations
Data

- All data was provided by the Norwegian Petroleum Directorate.
- Dataset consist of 1788 panel data observations from 109 petroleum fields on the NCS between 1970 and 2015.
- Independent variables consist of:
  - Crude oil price
  - Realized volatility of crude oil price
  - Number of exploration wells (wildcat appraisal)

**Figure**: Project process in oil & gas industry

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Plan for Development and Operations
Figure: Aggregate petroleum investment on the NCS (1970-2015)
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- **Estimation window**
- **Forecast window**

**Aggregate petroleum investment (bn. NOK)**

- 1970
- 1980
- 1990
- 2000
- 2010
- 2020

**Investment**

**Investment growth**

**Growth in aggregate petroleum investment**

- 0
- 50
- 100
- 150
- 200

**Aggregate petroleum investment (bn. NOK)**

- 0
- 50
- 100
- 150
- 200

- 1
- 1.5

- 0.5
- 5

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Figure: Crude oil price

- Crude oil (Brent) price (USD/bbl.)
- Logarithmic return of crude oil

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Figure: Realized volatility

Descriptive Statistic → Dependent variables
Figure: Exploration wells

Number of exploration wells (Wildcat & Appraisal)
Methodology

- Autoregressive Distributed Lag (ADL) model.

\[ y_t = \alpha + p \sum_{i=1}^p \beta_i y_{t-i} + q \sum_{j=0}^{q} \left( r \sum_{k=1}^r \gamma_{jk} x_{jt-k} \right) + u_t \quad (2) \]

Number of models tested: \[ m + q \sum_{i=1}^m m_i + 1 = 500 \quad (3) \]
Methodology

- Autoregressive Distributed Lag (ADL) model.
- Pseudo-out-of-sample forecast.

\[ y_t \equiv \ln(\text{Investment}_t) - \ln(\text{Investment}_{t-1}) \]  

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Number of models tested \[ = m + q \sum_{i=1}^{m_i + 1 \big( q_i \big)} = 500 \]
Autoregressive Distributed Lag (ADL) model.
Pseudo-out-of-sample forecast.
Re-specified and estimated for every subsample using information criteria.

Dependent variable:
growth in aggregate petroleum investment on the NCS.

Independent variables:
change in crude oil price, crude oil realized volatility & change in USD/NOK exchange rate.

\[ y_t \equiv \ln(\text{Investment}_t) - \ln(\text{Investment}_{t-1}) \] (1)

\[ y_t = \alpha + p \sum_{i=1}^{m} \beta_i y_{t-i} + q \sum_{j=0}^{r} (\sum_{k=1}^{m} \gamma_{jk} x_{jt-k}) + u_t \] (2)

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- Forecast accuracy evaluated with loss functions.

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- Statistical significance is evaluated with Diebold-Mariano test and Hansen-Lunde model confidence set procedure.

\[
y_t = \alpha + p \sum_{i=1}^{\infty} \beta_i y_{t-i} + q \sum_{j=0}^{\infty} (r \sum_{k=1}^{m_i} \gamma_{jk} x_{jt-k}) + u_t
\]
Methodology

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\[
y_t \equiv \ln(\text{Investment}_t) - \ln(\text{Investment}_{t-1}) \tag{1}
\]

\[
y_t = \alpha + \sum_{i=1}^{p} \beta_i y_{t-i} + \sum_{j=0}^{q} \left( \sum_{k=1}^{r} \gamma_{jk} x_{jt-k} \right) + u_t \tag{2}
\]

Number of models tested = \[ m + \sum_{i=1}^{q} m^{i+1} \binom{q}{i} = 500 \tag{3} \]
## Results

**Table: Regression result**

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>$\Delta \ln(\text{Investment}_t)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \ln(\text{Investment}_{t-1})$</td>
<td>0.278***</td>
</tr>
<tr>
<td></td>
<td>-2.82</td>
</tr>
<tr>
<td>$\Delta \ln(\text{Investment}_{t-2})$</td>
<td>-0.194</td>
</tr>
<tr>
<td></td>
<td>(-1.64)</td>
</tr>
<tr>
<td>$\Delta \ln(\text{Investment}_{t-3})$</td>
<td>0.280***</td>
</tr>
<tr>
<td></td>
<td>-3.56</td>
</tr>
<tr>
<td>$\Delta \ln(\text{CrudeOil}_{t-1})$</td>
<td>0.075</td>
</tr>
<tr>
<td></td>
<td>-0.86</td>
</tr>
<tr>
<td>$\Delta \ln(\text{CrudeOil}_{t-2})$</td>
<td>0.151*</td>
</tr>
<tr>
<td></td>
<td>-1.81</td>
</tr>
<tr>
<td>$\Delta \ln(\text{RealizedVolatility}_{t-1})$</td>
<td>-0.039***</td>
</tr>
<tr>
<td></td>
<td>(-3.47)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.011</td>
</tr>
<tr>
<td></td>
<td>-0.41</td>
</tr>
</tbody>
</table>

| N  | 42  |
| R2 | 0.425 |
# Results

**Table: Loss functions & Diebold-Mariano test**

<table>
<thead>
<tr>
<th></th>
<th>RMSE</th>
<th>MAE</th>
<th>ME</th>
<th>Hit rate</th>
<th>MZ-(r^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forecast models</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National budget</td>
<td>0.1406</td>
<td>0.1181</td>
<td>-0.0112</td>
<td>0.5</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>(0.20;0.96)</td>
<td>(0.23;0.78)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIC</td>
<td>0.0982</td>
<td>0.0849</td>
<td>-0.0087</td>
<td>0.7</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>(0.02;0.01)</td>
<td>(0.00;0.11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AICc</td>
<td>0.1217</td>
<td>0.0972</td>
<td>-0.0086</td>
<td>0.55</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>(0.01;0.29)</td>
<td>(0.00;0.47)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HQIC</td>
<td>0.1046</td>
<td>0.0895</td>
<td>-0.0134</td>
<td>0.65</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>(0.04;0.06)</td>
<td>(0.02;0.24)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIC</td>
<td>0.1115</td>
<td>0.0926</td>
<td>-0.0178</td>
<td>0.6</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>(0.05;0.11)</td>
<td>(0.01;0.33)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Adj. R2</td>
<td>0.106</td>
<td>0.0888</td>
<td>0.0004</td>
<td>0.75</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>(0.02;0.00)</td>
<td>(0.01;0.07)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Combined</td>
<td>0.1038</td>
<td>0.0858</td>
<td>-0.0096</td>
<td>0.65</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>(0.02;0.02)</td>
<td>(0.00;0.14)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Benchmark models</strong></td>
<td></td>
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<tr>
<td>Extrapolation</td>
<td>0.1671</td>
<td>0.1378</td>
<td>-0.0002</td>
<td>0.6</td>
<td>0.04</td>
</tr>
<tr>
<td>No Change</td>
<td>0.1398</td>
<td>0.1122</td>
<td>0.0438</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Table: Hansen-Lunde Model Confidence Set procedure

<table>
<thead>
<tr>
<th>Iteration</th>
<th>RMSE</th>
<th>MAE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T-Max</td>
<td>TR</td>
</tr>
<tr>
<td>1</td>
<td>Extrapolation</td>
<td>Extrapolation</td>
</tr>
<tr>
<td>2</td>
<td>NB</td>
<td>NB</td>
</tr>
<tr>
<td>3</td>
<td>No Change</td>
<td>No Change</td>
</tr>
<tr>
<td>4</td>
<td>AICc</td>
<td>AICc</td>
</tr>
<tr>
<td>5</td>
<td>BIC</td>
<td></td>
</tr>
</tbody>
</table>

Lorentzen & Osmundsen
Petroleum investment
11 / 14
Results

Figure: Forecast accuracy of national budget

Growth in aggregate petroleum investment

Actual
National Budget

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Petroleum investment

12 / 14
Results

Figure: Forecast accuracy of AIC specified ADL

ME = -0.0087   RMSE = 0.0982   MAE = 0.0849   MAPE = 4.2441   Hit rate = 0.70   MZ-R² = 0.49
Figure: Comparison between national budget & ADL
Findings:
- National budget does not significantly outperform the benchmark models.
- Autoregressive Distributed Lag models tend to significantly outperform the National budget and both benchmark models.

Implications:
- Growth in oil and gas investment on the NCS can be forecasted.
- Oil price, realized volatility of oil price and number of exploration wells as predictors of investment growth provide insight.
Thank you for your attention!
(Any questions?)