USE OF AIS-DATA TO ACHIEVE EFFICIENT SHIPPING

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Agenda

CSL and NHH

Energy efficiency and virtual arrival policy

The impact of regional environmental regulations on empirical vessels speeds
• 7 professors
• 3 assistant professors
• 1 researcher
• 5 PhD students

• LOGMS 2017 in Bergen in August
Energy efficiency and Virtual Arrival (VA) Policy

• Objective
  - To estimate the potential fuel savings and emission form implementing VA policy for VLCCs

• VA policy
  - Operational process with an agreement to reduce a vessel’s speed at sea to meet a required arrival time when the discharge port is congested and the delay is known
  - INTERTANKO and OCIMF initiated VA policy
  - Seldom implemented because of lack of reliable information of potential cost savings
    • Mandatory to monitor, review and consider operational practices and technology upgrades to optimize the energy efficiency performance

• AIS data – 2013-2015
• Fleet data – Clarksons WFR

Jia et al 2017
Data

• Fleet data – Clarksons

  WFR
  - 483 VLCCs
  - DWT, Design speed, design draught, pump capacity

• AIS data – 2013-2015
  - IMO number, vessel name, location, speed over ground, vessel draught, port of call
  - 5066 voyages between 410 ports
  - 55.5% voyages are laden

![Figure 1: Port time (days) histogram.](image)

- Average duration of port call is 4 days
- 80% of port calls are completed within 6 days
- Port time per vessels across time is stable
  Hence, port identity is the major influencing factor determining waiting time

NORWEGIAN SCHOOL OF ECONOMICS
Descriptive statistics

Table 1

<table>
<thead>
<tr>
<th>Unit</th>
<th>Port call duration days</th>
<th>Sailing time days</th>
<th>Port days/voyage days %</th>
<th>Sailing speed knots</th>
<th>Draught meters</th>
<th>Draught ratio(^a) %</th>
<th>DWT Tonnes</th>
<th>DWT/pump capacity hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>4.01</td>
<td>22.66</td>
<td>20.73%</td>
<td>11.26</td>
<td>16.28</td>
<td>75.60%</td>
<td>305,838</td>
<td>20.19</td>
</tr>
<tr>
<td>Median</td>
<td>2.72</td>
<td>20.24</td>
<td>13.56%</td>
<td>11.32</td>
<td>19.20</td>
<td>88.50%</td>
<td>303,994</td>
<td>19.43</td>
</tr>
<tr>
<td>Min</td>
<td>1.00</td>
<td>10.00</td>
<td>1.68%</td>
<td>7.01</td>
<td>7.00</td>
<td>33.92%</td>
<td>265,353</td>
<td>9.00</td>
</tr>
<tr>
<td>Max</td>
<td>47.33</td>
<td>71.19</td>
<td>357.28%</td>
<td>20.88</td>
<td>25.50</td>
<td>118.48%</td>
<td>323,182</td>
<td>63.69</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>3.71</td>
<td>10.52</td>
<td>22.80%</td>
<td>1.74</td>
<td>4.61</td>
<td>21.33%</td>
<td>10,022</td>
<td>7.26</td>
</tr>
<tr>
<td>Obs</td>
<td>5066</td>
<td>5066</td>
<td>5066</td>
<td>5066</td>
<td>4976</td>
<td>4976</td>
<td>5066</td>
<td>5066</td>
</tr>
</tbody>
</table>

\(^a\) Draught ratio = AIS_reported draught/Design draught.

- Draught ratio (reported draught vs design draught) is used for vessel payload
- Another study (Jia et al 2017) find that AIS-reported draught provides a good estimation of vessel payload.
Vessel payload

• Draught ratio below 70% is considered as ballast ratio
• The draught ratio and speed illustrates the clear separation between laden and ballast voyages in the tanker market

Fig. 2. Scatter plot of draught ratio vs. speed.
Estimating savings in fuel cost and emissions

• Fuel cost per voyage is calculated using 380Cst HFO price in Fujairah on day of departure
• Fuel consumption for the total voyage is calculated assuming that the draught ratio reflects displacement, engine type and AIS hourly speed data per voyage

\[ F_{i,j} = \sum_{t=1}^{T} \left( \frac{v_{i,j,t}}{v_{d,i}} \right)^3 \cdot \left( \frac{D_{i,j}}{D_{d,i}} \right)^{2/3} \cdot F_{d,i} \]

Fuel consumption per voyage.

F = fuel cost, \( V = \) speed, \( D = \) displacement, \( d = \) design, \( i = \) vessel \( i \), \( j = \) voyage \( j \), \( T = \) total voyage time, \( t = \) hour,

Emission is proportional to the fuel burned. Using the third IMO GHG study emission coefficients.
Impact of speed reduction from VA policy

- Implementing a virtual arrival policy and thereby reducing the sailing speed over the voyage give savings in fuel consumption and emissions.

- The flexibility to reduce speed in a VA policy depend on charter party clauses. Disregarded here.

\[
\Delta F_{ij} = 1 - \frac{F'_{ij}}{F_{ij}} = 1 - \left( \frac{v'_{ij}}{v_{ij}} \right)
\]

\( F_{ij} \) = average fuel consumption for vessel i on voyage j

\( F'_{ij} \) = new fuel consumption calculated using speed adjusted to VA policy adjusted longer time use made available by shortened waiting time.

(approximation because of non-linearity in the fuel consumption)
Assumptions

- Laden voyage: minimum time in port is the ratio between DWT and the vessel’s pump capacity
- Ballast voyage: minimum time for loading is 78 hours
- Considers 4 alternative voyage times; reducing excessive port time (waiting time) by 25%, 50%, 75% and 100%
- Minimum average sailing speed is 7 knots
## Fuels savings per voyage from VA policy

Table 5
Descriptive statistics for fuel savings per voyage based on VA policy (%).

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>I. 25% excess port Time reduction</th>
<th>II. 50% excess port Time reduction</th>
<th>III. 75% excess port Time reduction</th>
<th>IV. 100% excess port Time reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fuel saving</td>
<td>Port time (hr) saved</td>
<td>Fuel saving</td>
<td>Port time (hr) saved</td>
</tr>
<tr>
<td>Mean</td>
<td>7.26%</td>
<td>19.4</td>
<td>12.46%</td>
<td>36.8</td>
</tr>
<tr>
<td>Median</td>
<td>4.55%</td>
<td>11.7</td>
<td>8.56%</td>
<td>23.0</td>
</tr>
<tr>
<td>Min</td>
<td>0.00%</td>
<td>0.0</td>
<td>0.00%</td>
<td>0.0</td>
</tr>
<tr>
<td>Max</td>
<td>60.41%</td>
<td>192.3</td>
<td>70.27%</td>
<td>384.5</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>7.76%</td>
<td>21.6</td>
<td>11.67%</td>
<td>39.6</td>
</tr>
<tr>
<td>Obs</td>
<td>5013</td>
<td>5013</td>
<td>4917</td>
<td>4917</td>
</tr>
</tbody>
</table>
Emission reduction from VA policy – assuming 50% excess time reduction

<table>
<thead>
<tr>
<th></th>
<th>CO₂ (tonne)</th>
<th>CH₄ (kg)</th>
<th>N₂O (kg)</th>
<th>SOₓ (kg)</th>
<th>PM (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum</td>
<td>2,113,970.80</td>
<td>40,731.61</td>
<td>108,617.63</td>
<td>33,318.46</td>
<td>4,745,233.08</td>
</tr>
<tr>
<td>Mean</td>
<td>421.70</td>
<td>8.13</td>
<td>21.67</td>
<td>6.65</td>
<td>946.59</td>
</tr>
<tr>
<td>Median</td>
<td>271.82</td>
<td>5.24</td>
<td>13.97</td>
<td>4.28</td>
<td>610.15</td>
</tr>
<tr>
<td>Min</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Max</td>
<td>4,732.02</td>
<td>91.18</td>
<td>243.14</td>
<td>74.58</td>
<td>10,621.96</td>
</tr>
<tr>
<td>Std.Dev.</td>
<td>454.50</td>
<td>8.76</td>
<td>23.35</td>
<td>7.16</td>
<td>1,020.21</td>
</tr>
<tr>
<td>Obs</td>
<td>5,013</td>
<td>5,013</td>
<td>5,013</td>
<td>5,013</td>
<td>5,013</td>
</tr>
</tbody>
</table>
Fuel savings and Emission reduction from VA policy

- Calculation based on AIS data from 5066 voyages by 483 VLCC’s to over 200 oil terminals in the years 2013-2015
- Implementing VA policy may contribute to reducing emissions
- Fuel savings range from 7.3% with 25% reduction in excess port time, to 19% if all apparent inefficiencies can be removed
- CO₂ Emission reduction range from 240 tonnes for 25% reduction in excess port time, to 539 tonnes per voyage for 100% reduction in excess port time
The impact of regional environmental regulations on empirical vessels speeds

- AIS data on nearly 7000 ECA boundary crossings three years 2013-2015
- Stricter sulphur regulation inside ECA does not affect vessel speed in any economically significant manner
- Vessels speeds are not generally determined by fuel prices, but rather by voyage specific variables; e.g. weather
  - Or whether the vessel is heading towards or away from heavily trafficked areas or ports of call
  - Tanker or general cargo
  - Seasonal weather factors
Thank you for listening.