Maritime and Port-Related Big Data Developments

SmartPort Lunch Meeting

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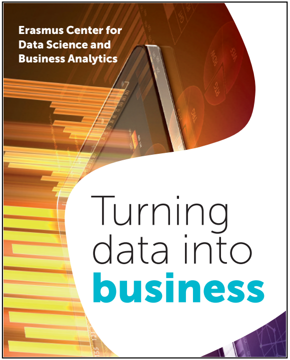
February 21st, 2017



Links:

http://www.erim.eur.nl/centres/data-science-business-analytics/
http://www.erim.eur.nl/centres/future-energy-business/
http://www.kenniswerkplaats-urbanbigdata.nl/

Past analysis based on proprietary data

Recent studies based on open data

The Hype

Opportunities by combining data sources

Big data and port performance

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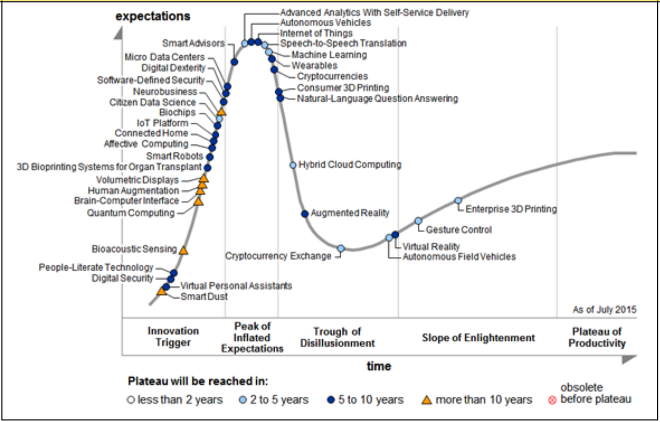
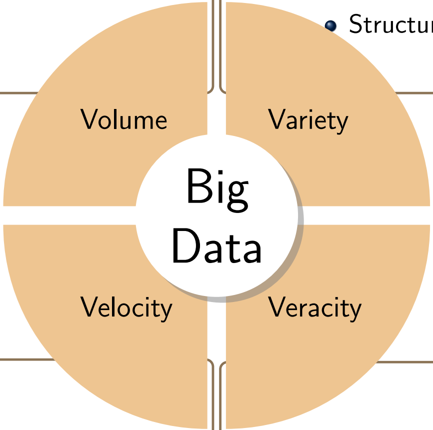
Gartner 2015 Hype Cycle: Big Data is Out, Machine Learning is in



- Sensor data
- Social media
- Biomedical data

- Unstructured
- Semi-structured
- Structured



- Data in flow
- Rate of generation and analysis

- Untrusted
- Uncleansed

Many interesting underlying issues

- Business opportunities of data solutions enormous
- Organizations, companies and governments alike, struggle with data-driven decision making
- Interplay between data and strategy requires specific mindset
- Serious issues concerning ethics, privacy, organizational image

Maritime and Port-related (Big) data applications

- Past research using proprietary data
- Recent data using open AIS data
- Opportunities by combining data sources
- Big data and port performance

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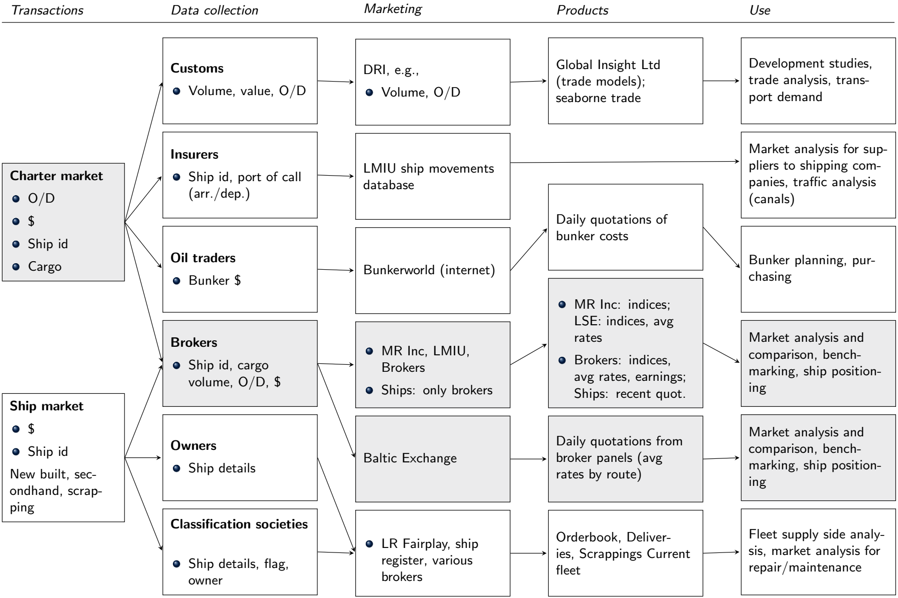
Past analysis based on proprietary data

Large-scale collection by many parties


Transactions
Data collection
Marketing
Products
Use
Charter market
O/D
$
Ship id
Cargo
Ship market
$
Ship id
New built, secondhand, scrapping
Customs
Volume, value, O/D
Insurers
Ship id, port of call (arr./dep.)
Oil traders
Bunker $
Brokers
Ship id, cargo volume, O/D, $
Owners
Ship details
Classification societies
Ship details, flag, owner
DRI, e.g.,
Volume, O/D
LMIU ship movements database
Bunkerworld (internet)
MR Inc, LMIU, Brokers
Ships: only brokers
Baltic Exchange
LR Fairplay, ship register, various brokers
Global Insight Ltd (trade models); seaborne trade
Daily quotations of bunker costs
MR Inc: indices; LSE: indices, avg rates
Brokers: indices, avg rates, earnings; Ships: recent quot.
Daily quotations from broker panels (avg rates by route)
Orderbook, Deliveries, Scrappings Current fleet
Development studies, trade analysis, transport demand
Market analysis for suppliers to shipping companies, traffic analysis (canals)
Bunker planning, purchasing
Market analysis and comparison, benchmarking, ship positioning
Market analysis and comparison, benchmarking, ship positioning
Fleet supply side analysis, market analysis for repair/maintenance

Fixture parties

Broker (MRI, Clarkson, SSY, etc)

Charterer (Cargill, Krupp, etc)

Owner (Bergenson, Cosco, etc)

Examples of fixtures

Erini (1982): Coal, Hroads-Antwerp; 125000-10%. Juli2030-FIO; 3,25 daysshinc25000tshinc (SwissMarin). 8.75$

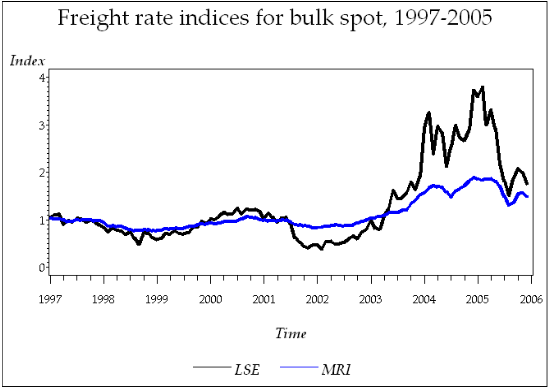
Bulk carrier spot contract for owner Erini with a ship built in 1982. The shipment involves coal, transported from Hampton Roads (USA) to Antwerp. Total tonnage is 125000$\pm$ 10%. The ship is expected in Hampton Road between 20 and 30 juli, free in and out. Loading may take 3.25 days including Sundays and holidays, at a rate of 25000 tons per day. Charterer SwissMarin agreed on a fixture price of 8.75$/ton.

Habil Duckling (1981): Hvy grains, River Plate-China; 55000-5%. Juli1525-FIO; 7000t5000t (Wilmar). 34.75$

Bulk spot contract between owner Habil Duckling and charterer Wilmar to ship 55000$\pm$ 5% tons heavy grain from River Plate (Argentina) to China at a rate of 34.75$/ton. Loading starts between 15 and 25 July.

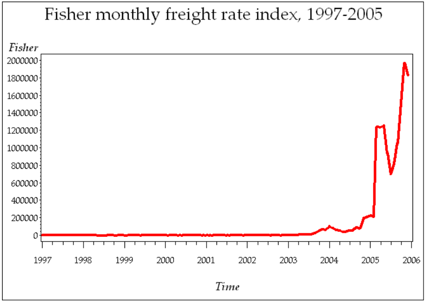
Past analysis based on proprietary data

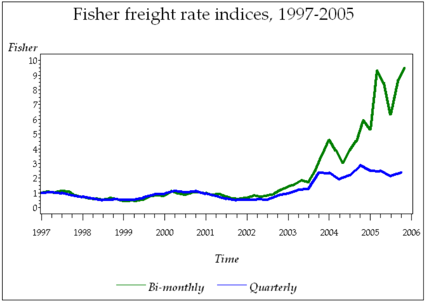
Ocean freight indices



- Published freight rate indices (LSE, MRI) widely diverge[1]
- Background existing indices roughly known (size-weighted unit-value indices), but not in detail (e.g. information used)

[1] Veenstra, A.W. and J. van Dalen, 2011, Fixtures-Based Freight Rate Indices, and Their Impact on Freight Rate Modeling in the Shipping Industry. In: K. Cullinane (ed) *The International Handbook of Maritime Economics*, chapter 19, Edward Elgar Publishing, isbn: 1847209335, 63-84.

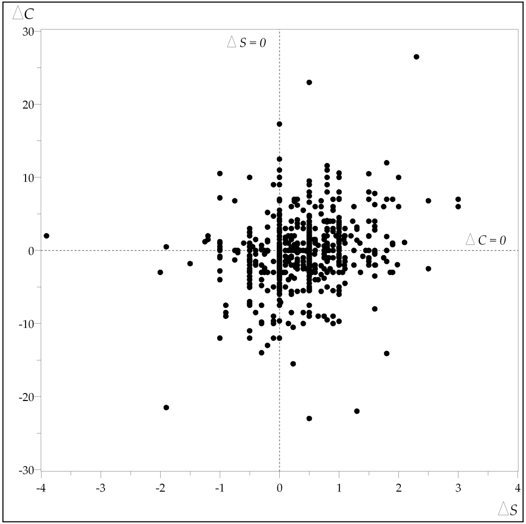




- Initial matched model (ship) indices showed very unusual patterns, prone to time window considered
- Takeaways: re-consideration notion of a 'product' and its associated 'price', choice of aggregation basis (route, type of contract) matters, indices diverge in periods with sparse data, role of expert opinion not always clear

Past analysis based on proprietary data

Fuel and speed in time charter contracts



- Speed loss (ΔS),: warranted minus actual speed
- Excess fuel consumption (ΔC): actual minus warranted consumption
- Charterers can claim the owner, if fuel consumption is more than warranted, or speed is less than warranted
- A substantial amount of variation is within ship[2]

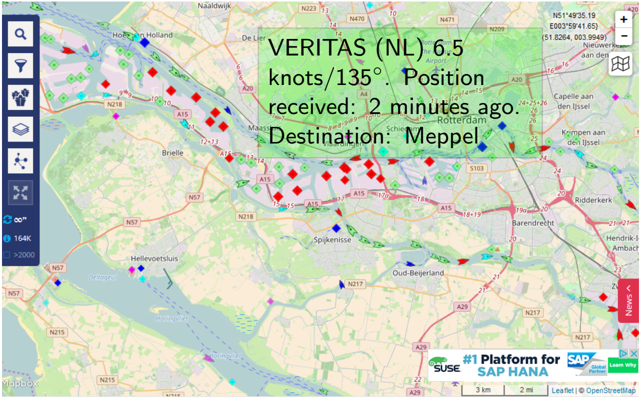
[2] Veenstra, A.W. and J. van Dalen, 2011, Ship Speed and Fuel Consumption Quotation in Ocean Shipping Time Charter Contracts, *Journal of Transport Economics and Policy* (JTEP), 45(1), 41-61.

Past analysis based on proprietary data

Recent studies based on open data

Opportunities by combining data sources

Big data and port performance



Source: `https://www.marinetraffic.com/`

- AIS (Automatic Identification System) data generated by ships using transponders, both ocean-going inland-water ships
- At scale collected and sold by, e.g. MarineTraffic, AISHub, VT Explorer

- Together with Teqplay and two master students we explored the potential use of AIS data for: (*i*) measuring emissions in the port area as a result of inland shipping; and (*ii*) supporting loading decissions depending on predicted water depth

;

Recent studies based on open data

Low water levels

- Recent years have seen sustained periods of low water levels in inland waterways
- These low water levels seriously affect transportation

Rhine river's low water levels causing ships to run aground

The Rhine river, near Neuss. Photo: DPA.

DPA/The Local
news@thelocal.de

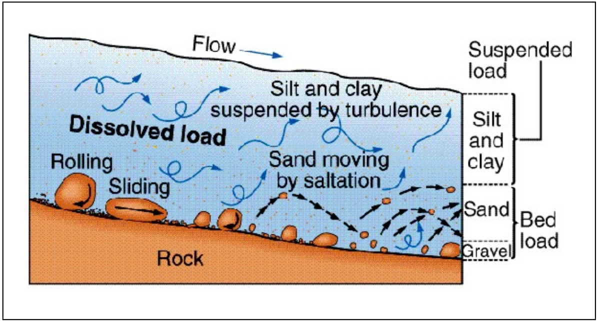
13 October 2016 | 14:50 CEST+02:00

The Rhine river, a major shipping waterway through western Germany, is experiencing worringly low water levels, causing problems for vessels along the major shipping route.

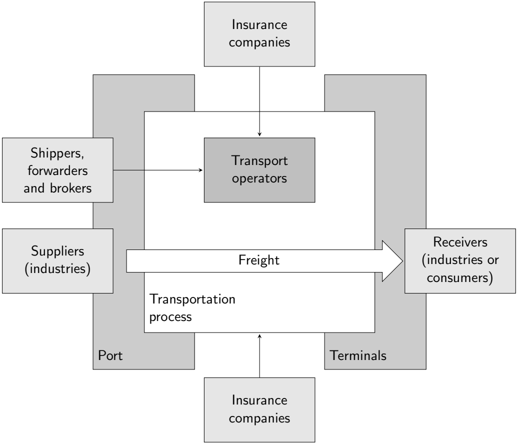
The Rhine's water level between Bonn and Duisburg, North Rhine-Westphalia, measured this week at 2.14 metres - less than half of its normal depth of 4.33.

Source: `http://www.thelocal.de/20161013/low-water-levels-on-rhine-river-causing-ships-t`

- Apart from water supply, water levels are determined by sediment transport
- This dynamically changes water levels in the sense that underwater dunes may form at short notice

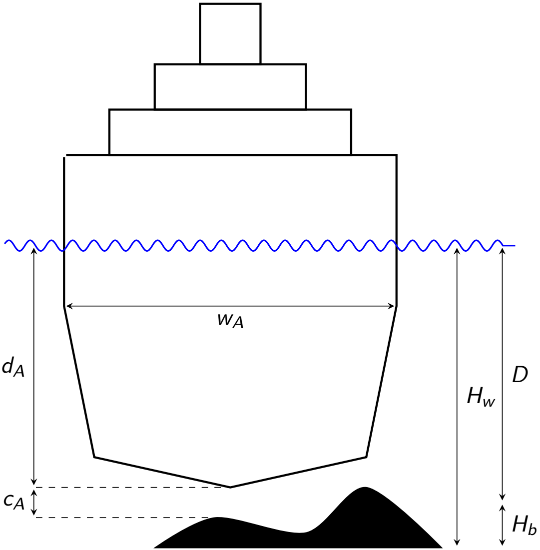


Source: `http://www.personal.kent.edu/~sclement/dynamics/rivers/rivers.htm`



Stakeholders in inland water way transportation (source: Cindy Zwaan, 2016)

- Low water levels affect a range of stakeholders in addition to barge operators: shippers, suppliers, customers, insurance companies.
- Water levels immediately impact loading decisions of barge operators as well as the route selected for sailing
- Accurate information about water levels, or rather water depth is therefore highly relevant



Measure water depth

Water depth D can be measured in different ways:

- Ship-related: $D = d_A + c_A$
- Riverside-related: $D = H_w - H_b$

The latter is relatively static, and does not considering changing water bed conditions

The idea[3]

- If one knows a ships draft d_A (which will be relatively stable while sailing) and measures keel clearance (e.g., via echo), then water depth can be measured dynamically
- Project Covadem actually based on this idea, but has relatively small scale, and based on echo sounders
- Instead, water depth may be measured using AIS data by exploiting the physical relation between draft, speed and water depth
- Some problems: measuring draft, finding the precise relation between draft, speed and depth, and doing the empirical analysis

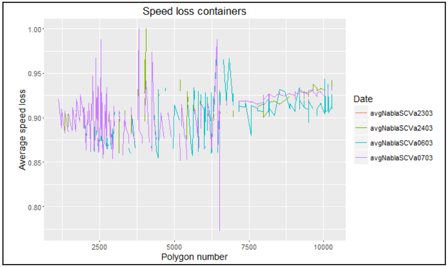
[3] Cindy Zwaan, 2016, *The effect of low water levels on loading decisions in the Northwest European inland waterways network*, Master thesis Rotterdam School of Management, Erasmus University.

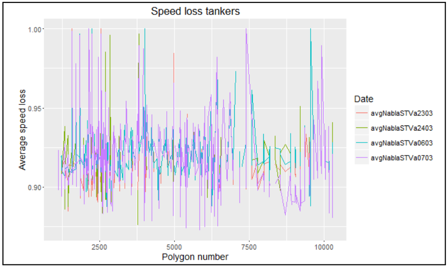
- Problems partly solved by physical between between speed in deep and shallow water on the one hand and ship and water characteristics on the other hand[4]:

$$\frac{V(\infty) - V(h)}{V(\infty)} = 0.1242\left(\frac{A}{h^2} - 0.05\right) + 1 - \tanh\left(\frac{A}{V(\infty)^2}\right)^{0.5}$$

- Unknowns: ship's speed in deep water $V(\infty)$, ship's speed in shallow water $V(h)$, submerged midsection A and water depth h
- Once $V(\infty)$, $V(h)$, and h are obtained, loading decisions can be supported using the identity $A = w_A \cdot d_A$

[4] Lackenby, H. 1963, The effect of shallow water on ship speed, *Shipbuilder and Marine Engineer*, **70**, 446-450.

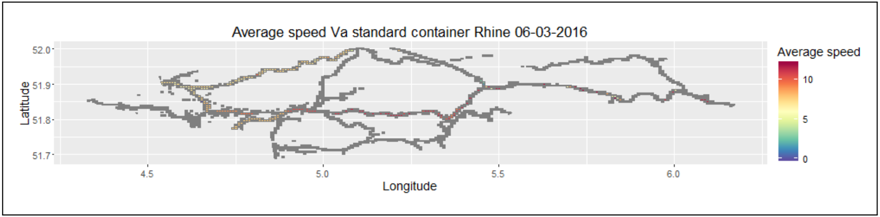


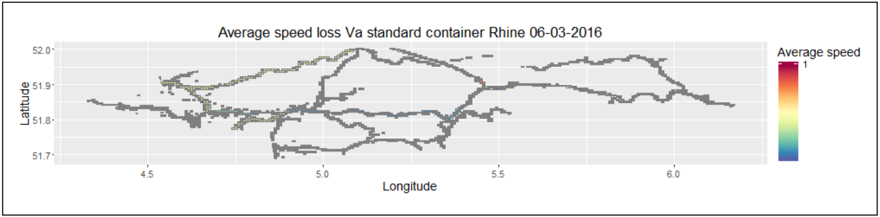


Average speed losses of container ships and tankers by designated area (polygon), March 6th 2016

Clearly, the speed losses by tankers tend to be more volatile than the speed losses by container ships

By way of impression, the maps below show the average speed and average speed loss of container ships on the Rhine, March 6th, 2016





Recent studies based on open data

Environmental effects of port activity

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Opportunities by combining data sources

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Opportunities by combining data sources

Unplanned tram stops and bridge openings

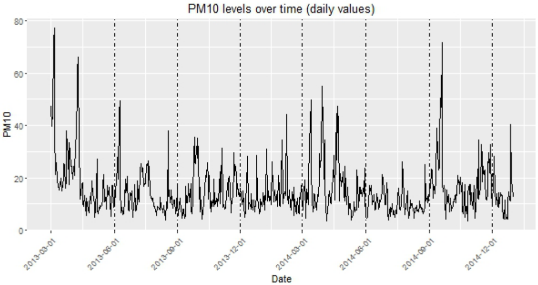
- Unplanned tram stops
- Data about unplanned tram stops and bridge openings

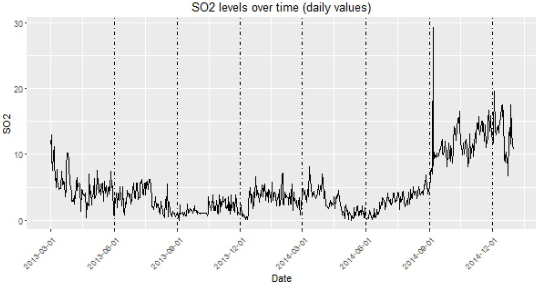
Bridge	Constant	Variable
Coolhavenbrug	1870.8	9.2
Parkhavenbrug	2115.8	6.5
Erasmusbrug	483.9	70.2
Lage Erfbrug	288.1	10.7

- Stop duration (in seconds) varies with opening duration (minutes)
- For example: every opening of Erasmusbrug comes with a fixed time loss of 484 seconds (or 8 minutes) plus a bridge-opening dependent loss of 70 seconds per opening minute.
- The variable costs alone have been estimated €25k per year

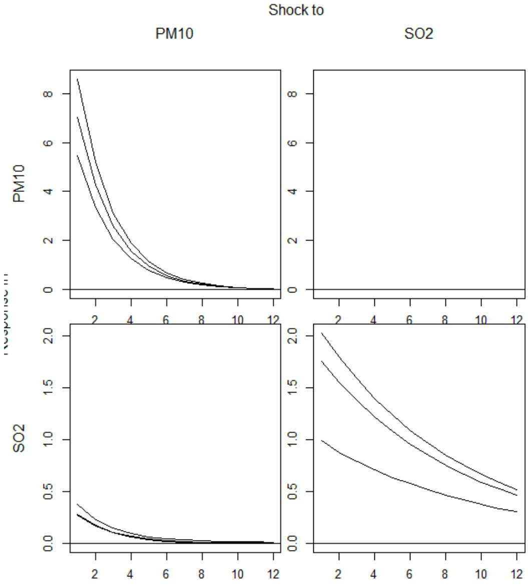
Opportunities by combining data sources

Emissions, traffic and the weather





- Emissions, traffic and the weather (Dublin open data)
- Emission sensors (PM10, SO2, NOx) and nearby traffic sensors



- Emissions, traffic and the weather (Dublin open data)
- Emission sensors (PM10, SO2, NOx) and nearby traffic sensors
- Example: increases in particle matter come with increased emission gasses (not the other way around); rain reduces observed emissions, wind increases measured emissions

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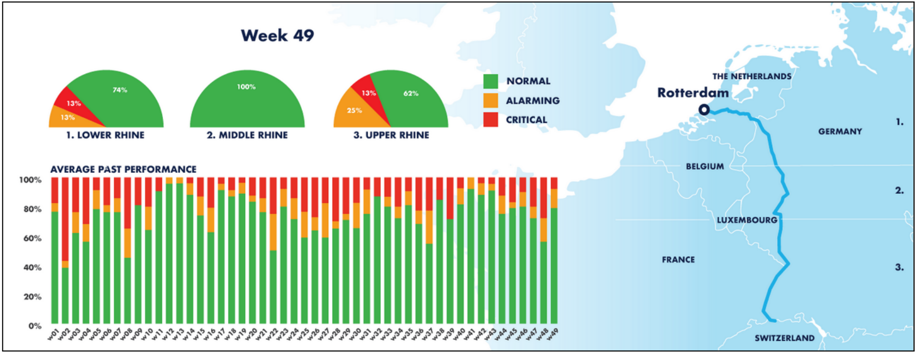
Forecasting dwell times of inland shipping in the Port of Rotterdam

- Barge performance monitor:[5] comparison of dwell time of individual ships with the average dwell time of the same ship over the past year
- Dwell times based on AIS data

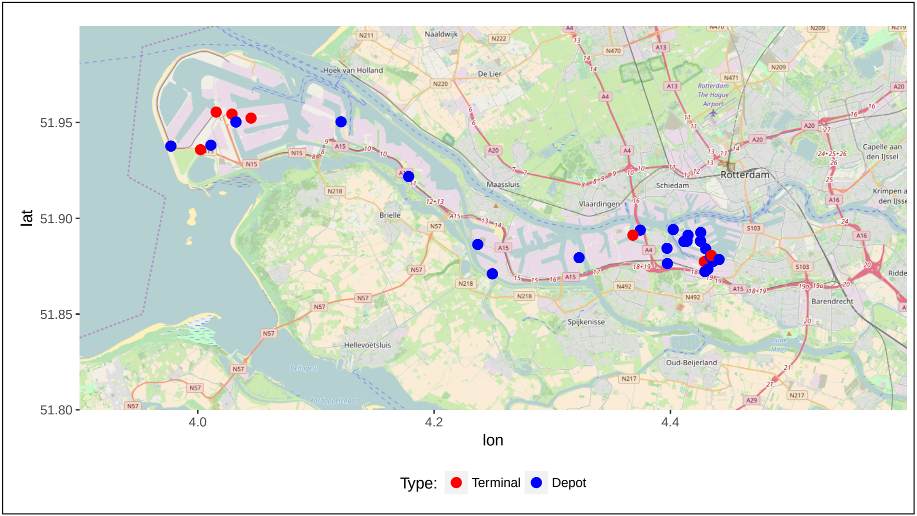


[5] *Source*: `https://www.portofrotterdam.com/nl/verbindingen-logistiek/intermodaal-transport/barge-performance-monitor`

Forecasting dwell times of inland shipping in the Port of Rotterdam[6]

- Existing barge performance operator based on a pilot, and is backward looking
- Interest is in dwell time forecasts to support transport decisions by individual shippers (long, avoidable dwell times are a waste of time and resources)
- These dwell time forecasts are preferably based on open data
- Objective of the TNO proposal is to develop such a forecast model and assess the added forecast value of open data sources; the project's outcome should be an easy to communicate future dwell time indicator

[6] Based on recently accepted TNO proposal with the same title.


lat
51.95
51.90
51.85
51.80
4.0
4.2
4.4
lon
Type:
Terminal
Depot
Hoek van Holland
Naaldwijk
De Lier
Maassluis
Vlaardingen
Schiedam
Rotterdam
Brielle
Hellevoetsluis
Spijkenisse
Oud-Beijerland
Barendrecht

Sea side:

- number of sea side terminals
- sailing schedule
- call size
- weather conditions

Port activity:

- number of ships at quays, sea-going ships and barges
- number of ships waiting in port area
- observed current and past dwell times
- terminal maintenance schedule

Hinterland:

- number and types of ships approaching
- opening times hinterland terminals
- maintenance schedule hinterland terminals
- seasonal patterns
- data road haulage

Some Challenges

- Collecting the data into coherent framework may prove to be less than straightforward
- Uncertainties about destinations and travel times of ocean-going ships and barges
- Dwell time not a linear relation of the number of ships. Interdependence of ships' activities in the port area may adversely affect the quality of econometric estimates (calling, instead, for simulation-based approaches)