Delays for passenger trains on a regional railway line in southern Sweden

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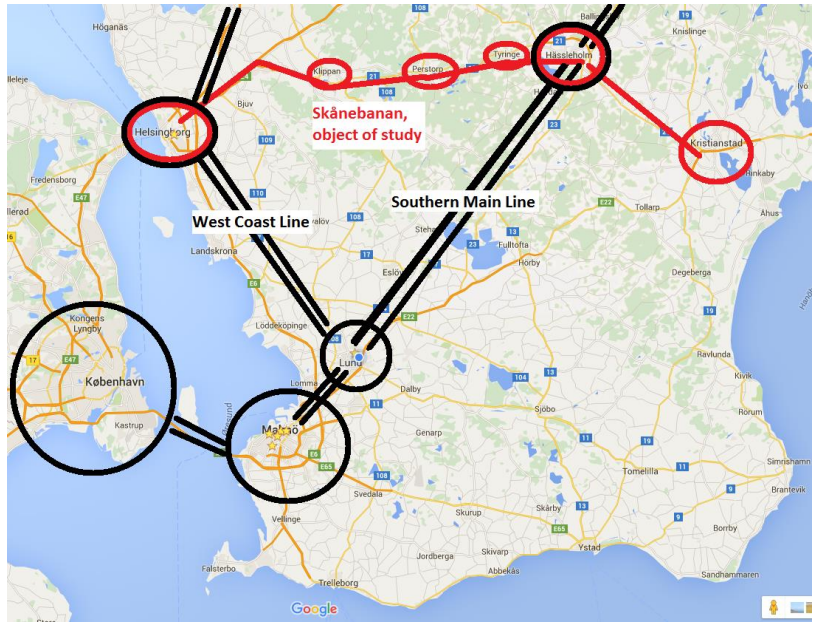
Concept

- Pilot study
  - One electrified single track line, 113 km
  - Mixed traffic, high capacity utilization
  - One full year of traffic, 560.000 observations
- Study minor delays:
  - When and where they occur
  - Which factors contribute, and by how much
- Improve timetable design
  - Choice of dwell time at stations
  - Size and distribution of run time supplements



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Brief background

- Vromans, 2005:
  - Size and distribution of supplements in a timetable is important
- Ceder & Hassold, 2015:
  - Heavy passenger loads often leads to increased dwell times, main cause for delays in New Zeeland
- Harris, Mjøsund & Haugland, 2013:
  - Most delays at stations are small, poorly recorded and not well understood
- Xia et al., 2013:
  - Wind, snow, precipitation, temperature and leaves contribute to infrastructure disruptions

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Data and variables used

- Train movement logs
  - Actual durations, earlier delay, weekday and month
- Detailed timetables
  - Scheduled durations, time supplements
- Weather data
  - Precipitation, snow depth, temperature
- Capacity utilization
  - Daily and peak values for line segments

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Delay analysis 1/4: Line vs stations

- Where do delays occur?

	Summary statistics		Probability of finishing activity …			
	Average delay	Standard deviation	Early	On time	Delayed	Delayed by more than 100%
Line section	0,00	0,01	24%	58%	18%	0%
Station stop	0,44	1,21	19%	34%	47%	41%

- Delays are much larger and more common at stations, than on line sections

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Delay analysis 2/4: Overview of impacts

Input		Welch's t-test	Linear regression	
Variable	Source	p-value	Coefficient	p-value
Earlier delay of train	Line section	0,00	0,00	0,00
	Station stop	0,00	-0,05	0,00
Scheduled duration relative to average	Line section	0,27	0,00	0,00
	Station stop	0,00	-0,22	0,00
Margins in timetable	Line section	0,00	-0,01	0,00
	Station stop	0,00	0,00	0,00
Temperature	Line section	0,00	0,00	0,00
	Station stop	0,00	0,00	0,01
Precipitation	Line section	0,05	0,00	0,00
	Station stop	1,00	0,00	0,39
Snow, depth	Line section	0,00	0,02	0,00
	Station stop	0,00	-1,16	0,00
Day of week	Line section	0,00	0,00	0,00
	Station stop	0,01	-0,01	0,00
Month of year	Line section		0,00	0,00
	Station stop		0,02	0,00
Capacity utilization calculated daily	Line section		0,01	0,00
	Station stop		0,06	0,00
Capacity utilization calculated at peak	Line section		-0,01	0,00
	Station stop		-0,03	0,10

- Step 1: Welch's t-test
  - The impact of most variables was significant
  - The impacts of precipitation and run time were not
- Step 2: Linear regression
  - Mostly significant but small coefficients
  - Larger coefficients for snow depth and dwell time at stations
  - Precipitation and peak capacity utilization at stations were not significant

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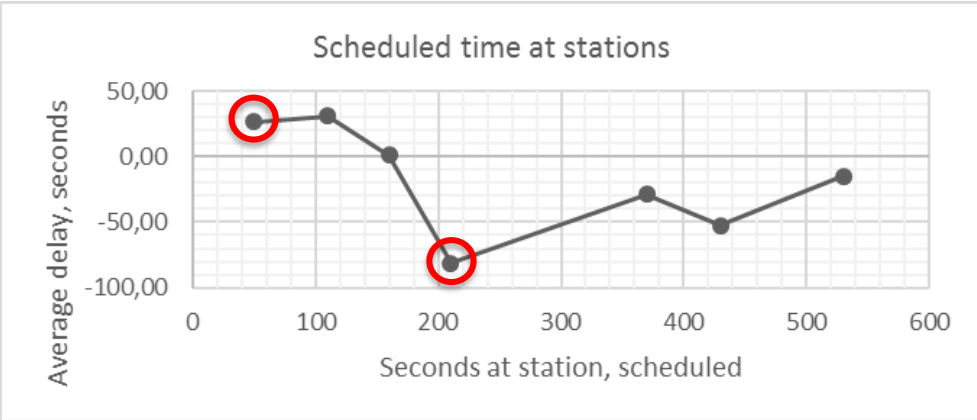
Delay analysis 3/4: Dwell times

- Step 3: Visual analysis
- Scheduled time at stations
  - Most important variable
  - Usually too short
  - Reallocation possible
    - » Clear difference in efficiency
    - » Using only existing dwell time
    - » Could reduce delays by 80%



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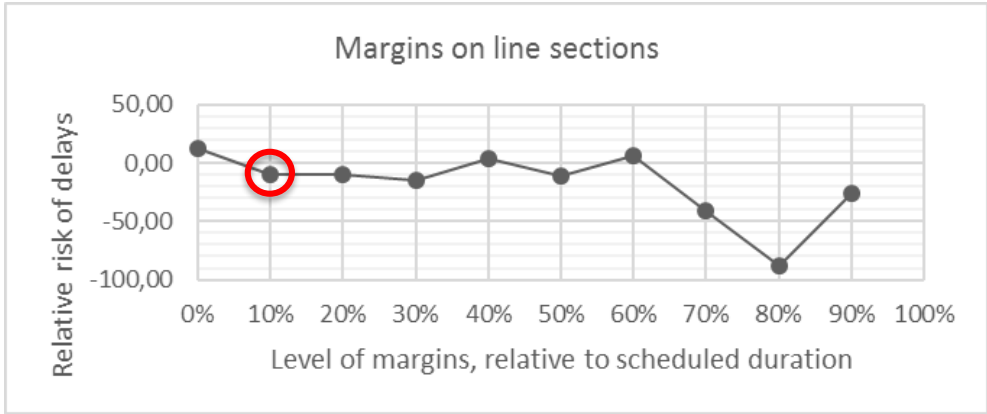
Delay analysis 4/4: Run time supplements

- Step 3: Visual analysis
- Supplements on line sections
  - Small supplements very helpful, large supplements are wasted
  - Little effect in absolute terms, these delays are small and rare



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Conclusions and future research

- Almost all of the effects are non-linear
  - Will continue analysis using neural networks
- Timetable design is crucial
  - Run time supplements should be small and evenly distributed
  - Greater effort should be put into choosing appropriate dwell times
  - More thorough timetable analysis is warranted, and coming
- Other factors do matter, but much less
  - Now checking across the national network, 2013-2015
  - Will add more explanatory variables

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