Variation of Restoration Time for Switch Failures on the Swedish Railway Network

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SWITCHES

- Switches and Crossings (S&Cs) are components of track designed to enable one track to either cross, diverge from or merge into another track.

- They enable flexibility within the railway network by allowing trains to ‘change direction’

- They have many discontinuities, experience high dynamic forces & hence prone to failure

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SWITCH FAILURES & DELAYS

Switches are both a cost & unreliability driver in railway maintenance and operation.

- ✓ Atleast 13% of maintenance cost on the Swedish Railway Network
- ✓ 21% of total hours of train delays attributed to Infrastructure Failures in Sweden
- ✓ Similarly, 19% delay minutes on the German railway network in 2010, as reported by Deutsche Bahn

Failures (and subsequent delays) will be exacerbated by the anticipated growth in train traffic linked to

EU's mode shift target of 30% by 2030 & 50% by 2050

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EU's MODAL SHIFT TARGET-IMPLICATIONS

Shift 30% of road freight traveling over 300km to rail and waterborne transport by 2030, and over 50% by 2050, have most medium-distance passenger journeys of less than 3hrs (400-1000 km) made by rail by 2050.

- ✓ Higher utilisation of the network = More frequent failures
- ✓ Optimised use of network capacity = Less tolerance of disruptions (Random Failures)

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RESEARCH GAP and QUESTIONS

- ✓ Limited studies focus on unplanned emergency maintenance in Sweden, let alone emergency maintenance of switches
- ✓ Can primary delays be modelled through network restoration times ?

RESEARCH QUESTIONS

- ❑ How long does is it take to restore the railway network in the event of switch failures?
- ❑ How does this restoration time vary across the network?
- ❑ What is the impact of restoration time on train delays? (Future work)

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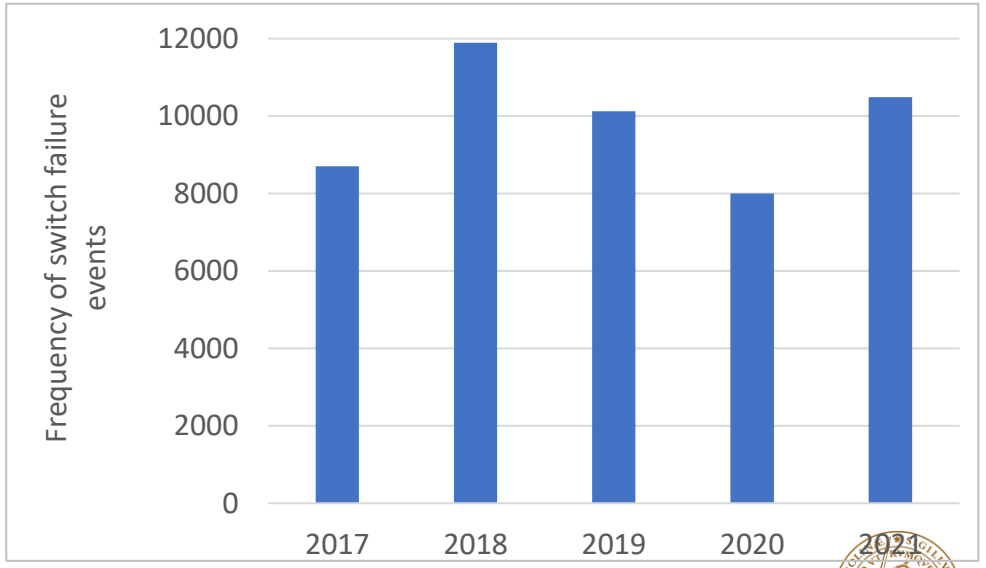
Method

Data: 49,194 Switch failure events for a 5-year period (2017-2021) obtained from Ofelia; Sweden's report system for infrastructure failures. Sweden has ca 15,590 Switches (BIS,2017)

Each failure event is described by

- ✓ Delay codes
- ✓ Failure description (text)
- ✓ Timestamp of the occurrence of the fault (Reported time)
- ✓ Timestamp of arrival of maintenance team on site
- ✓ Timestamp of complete remedy of fault (Remedy time)



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Method

Derive as: Restoration time = Response time + Repair time

- ✓ Response time = Arrival time – Reported time
- ✓ Repair time = Remedied time – Arrival time

Graphical Visual & Statistical Analysis

- ✓ Main statistical parameter: Median, 2hrs as a baseline, 95th Percentile

Structure of presentation

- ✓ Temporal (Annual/Monthly), Geographical location, Track type

Results

- ✓ Failures per day, Restoration time per failure, Downtime per day

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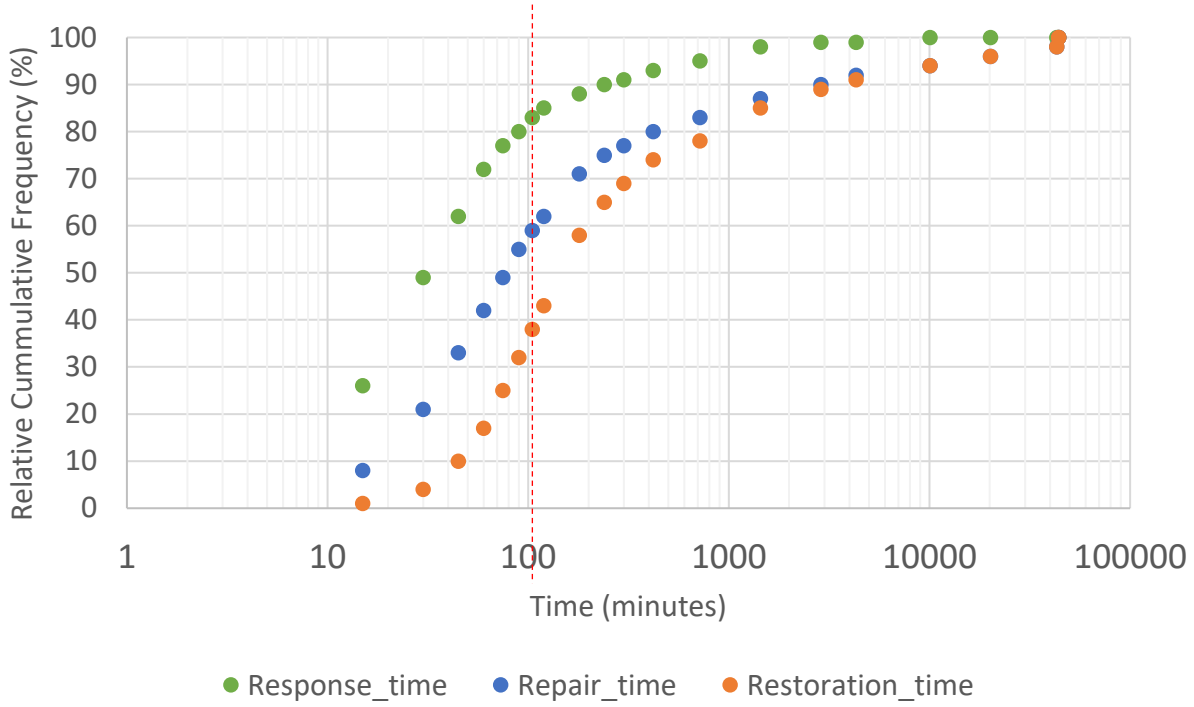
Restoration time-Swedish Railway Network



- Median Restoration time for Switch Failures = (144 minutes) 2.4hrs
- Only 43% remedied within 2hrs (120 minutes)

	Median (mins)	<120minutes	IQR (min)	95th Percentile (hrs)
Response time	32	84%	55	13
Repair time	77	62%	211	201
Restoration time	144	43%	391	220

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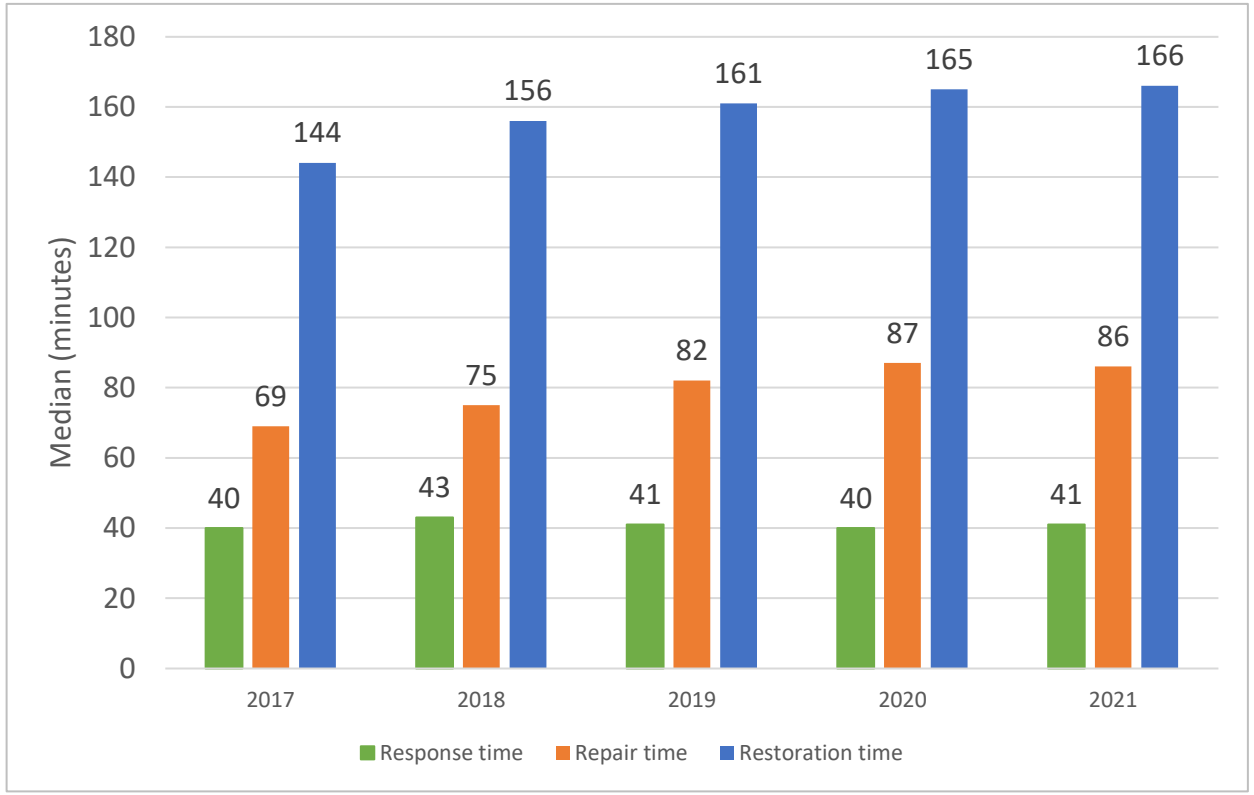
Annual Variation



- Response time is constant across the years
- Repair & Restoration times show consistent annual increase

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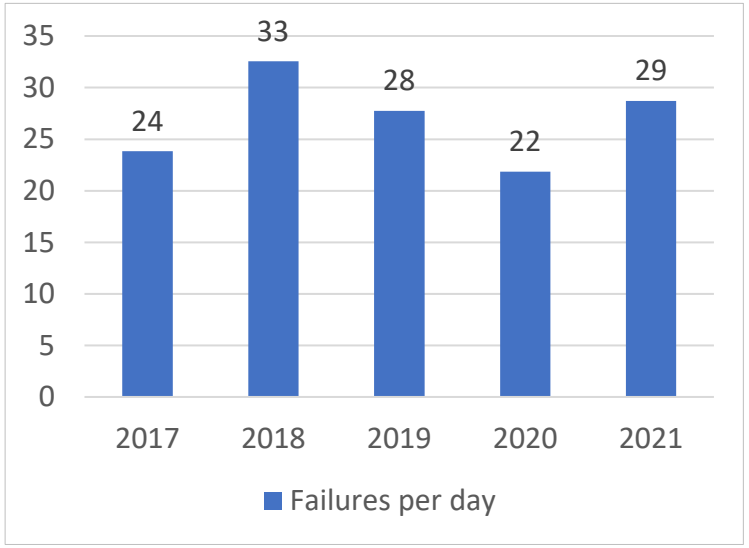
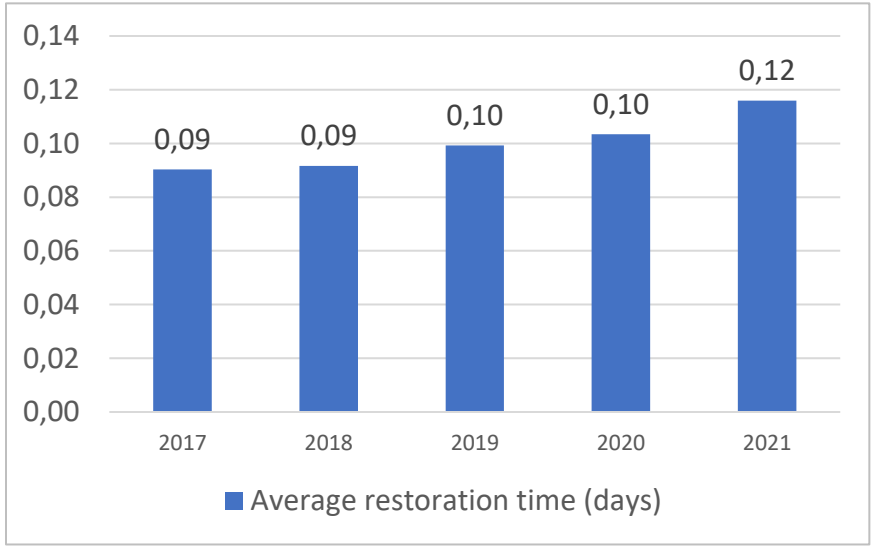
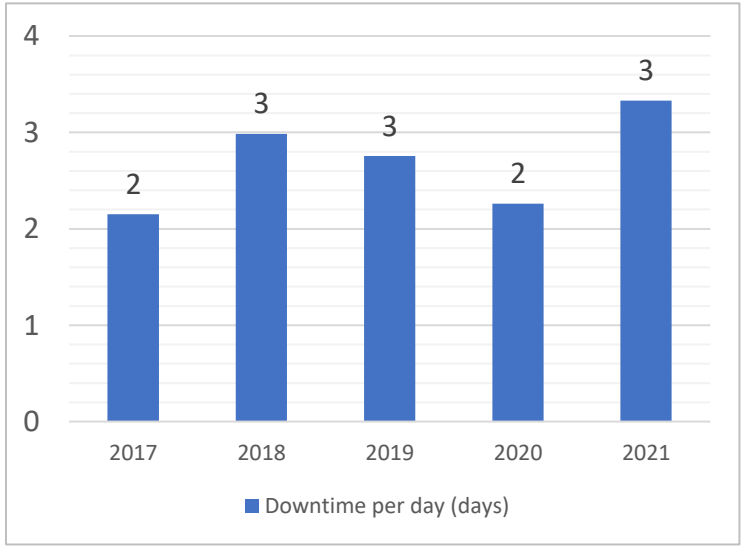
Annual Variation







✓ 27 failures per day

✓ 2,4hrs restoration time per switch failure

✓ 3 days' downtime per day

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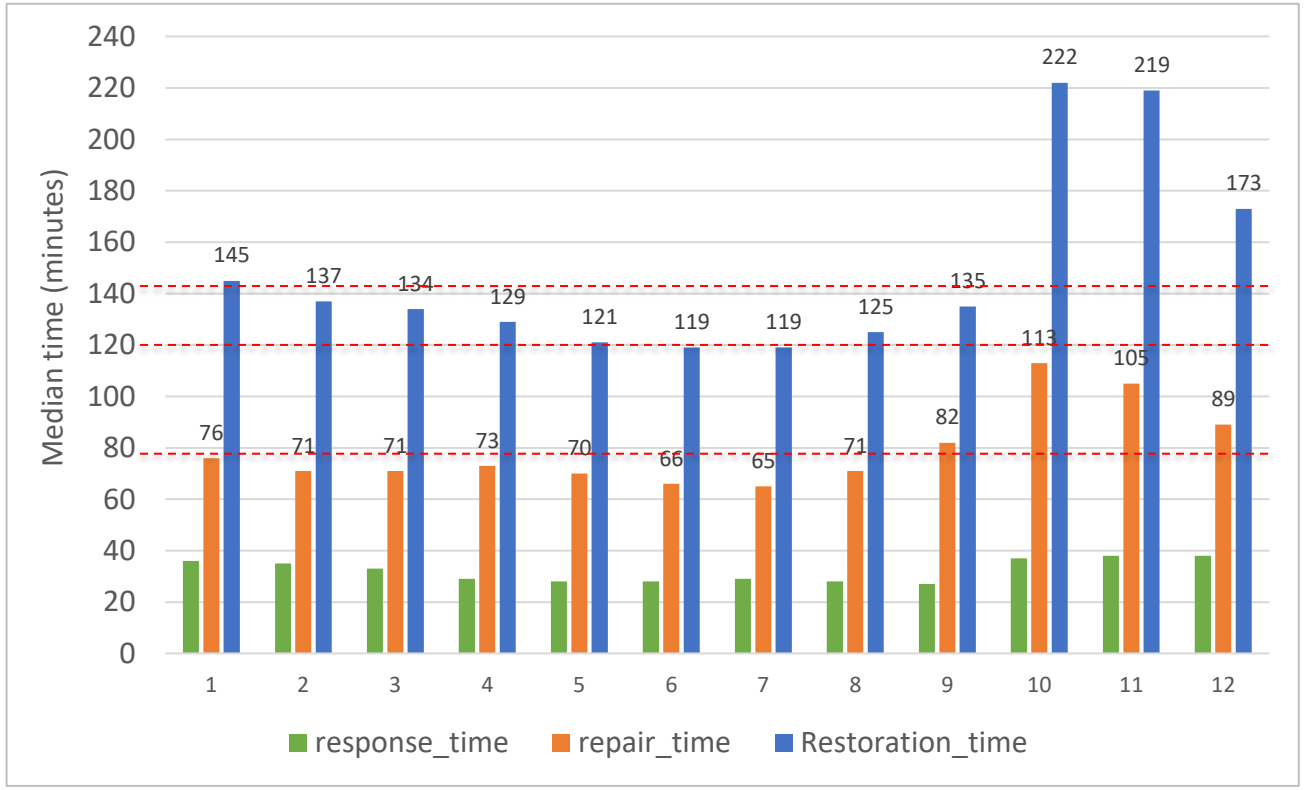
Monthly Variation



- Response time constant throughout the year
- Repair & Restoration times shortest during summer period May-July
- Restoration times longest in October, November, December & January i.e, above global median of 144 minutes
- Repair times longest in winter i.e., longer than global median of 77 minutes

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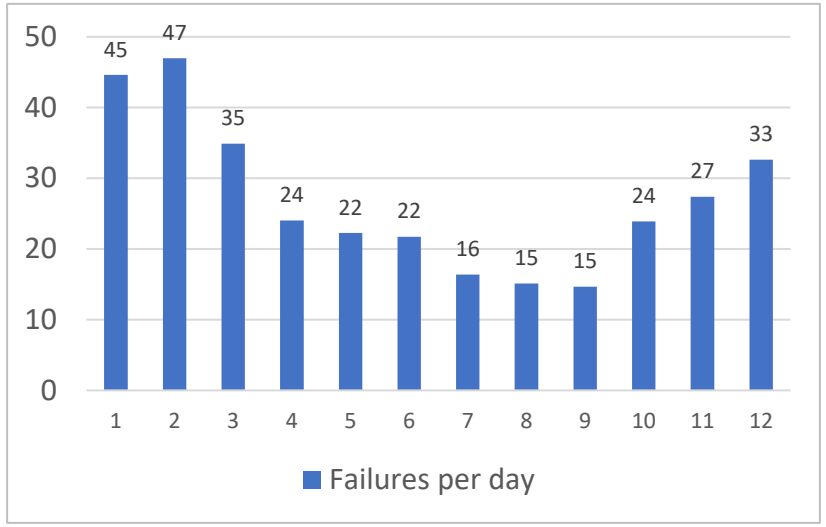
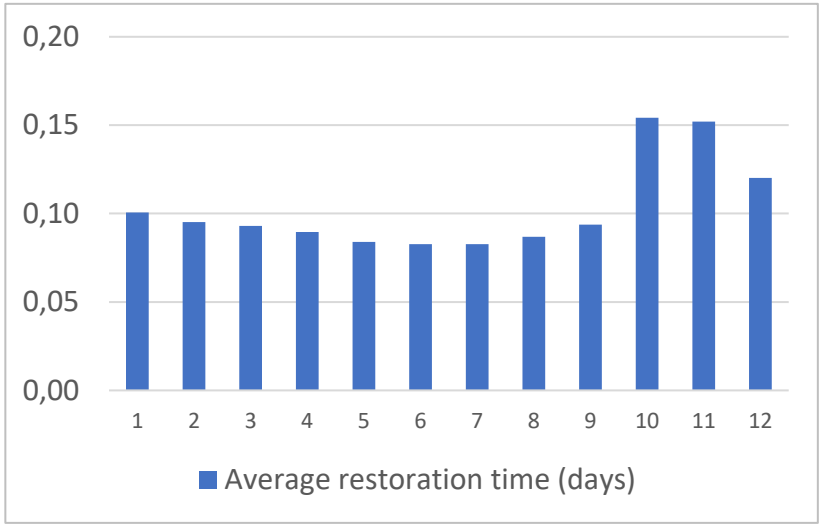
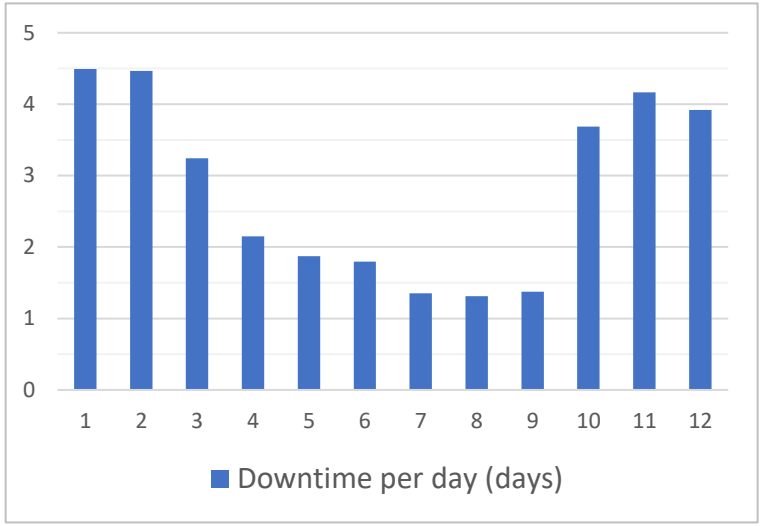
Monthly Variation







- ✓ Monthly increase in failures per day from Oct – Feb
- ✓ Monthly decrease from Mar-Sep

- ✓ Dec-Sep: 2,4hrs Average restoration time
- ✓ Oct-Nov: 3,6 hrs Average restoration time

- ✓ Oct-Feb: 3 days downtime/day
- ✓ Mar-Jun: 2 days downtime/day
- ✓ Jul-Sept: 1 days downtime/day

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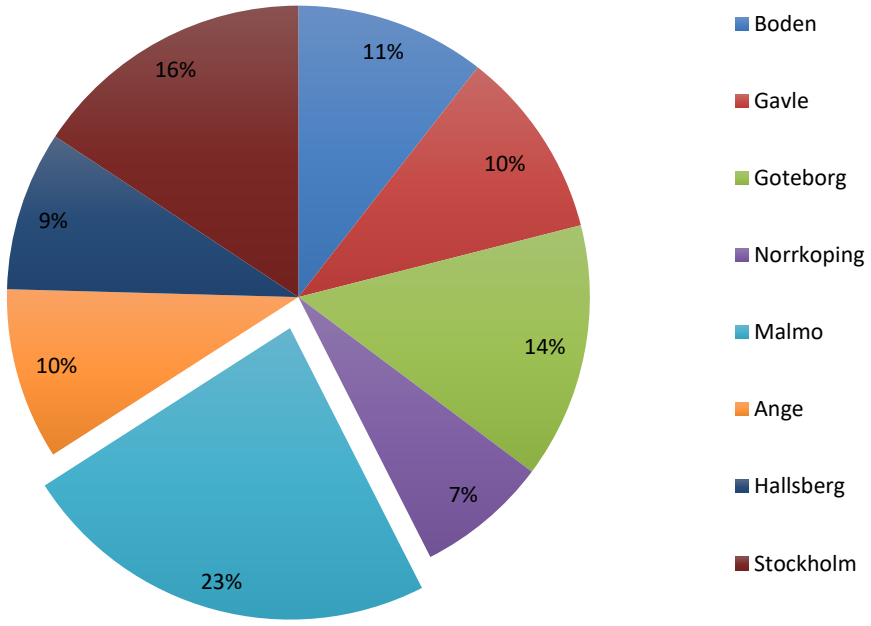
Variation across geographical location

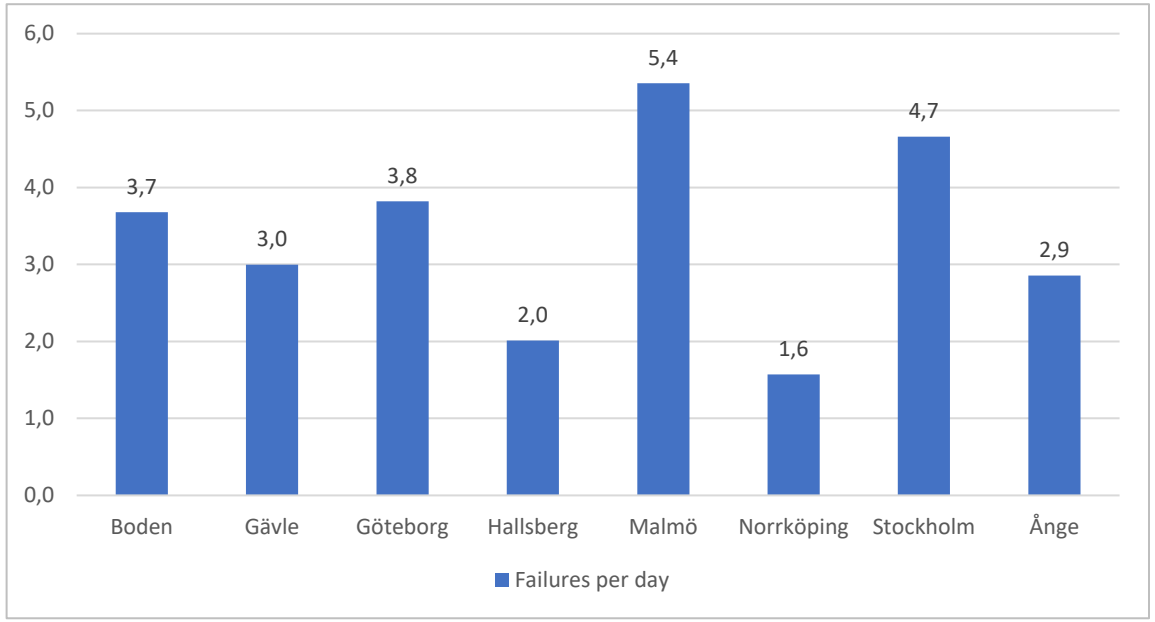
- ✓ Classified on basis of Trafikverket Traffic Control Areas

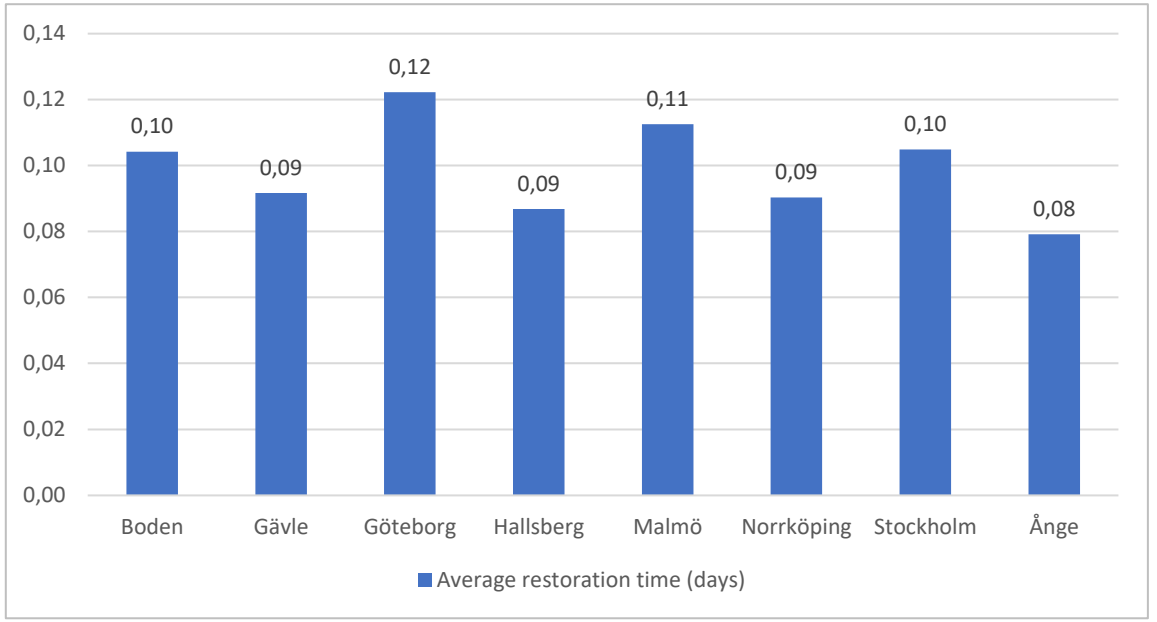
Frequency distribution of Switch failures



Source: https://bransch.trafikverket.se/for-dig-i-branschen/jarnvag/trafikledning/

Variation across geographical location





- Failure rates similar for Gavle & Ange; Boden & Goteborg; Hallsberg & Norrkoping; Malmo & Stockholm

- Average restoration time is 0.1 days (2,4hrs)

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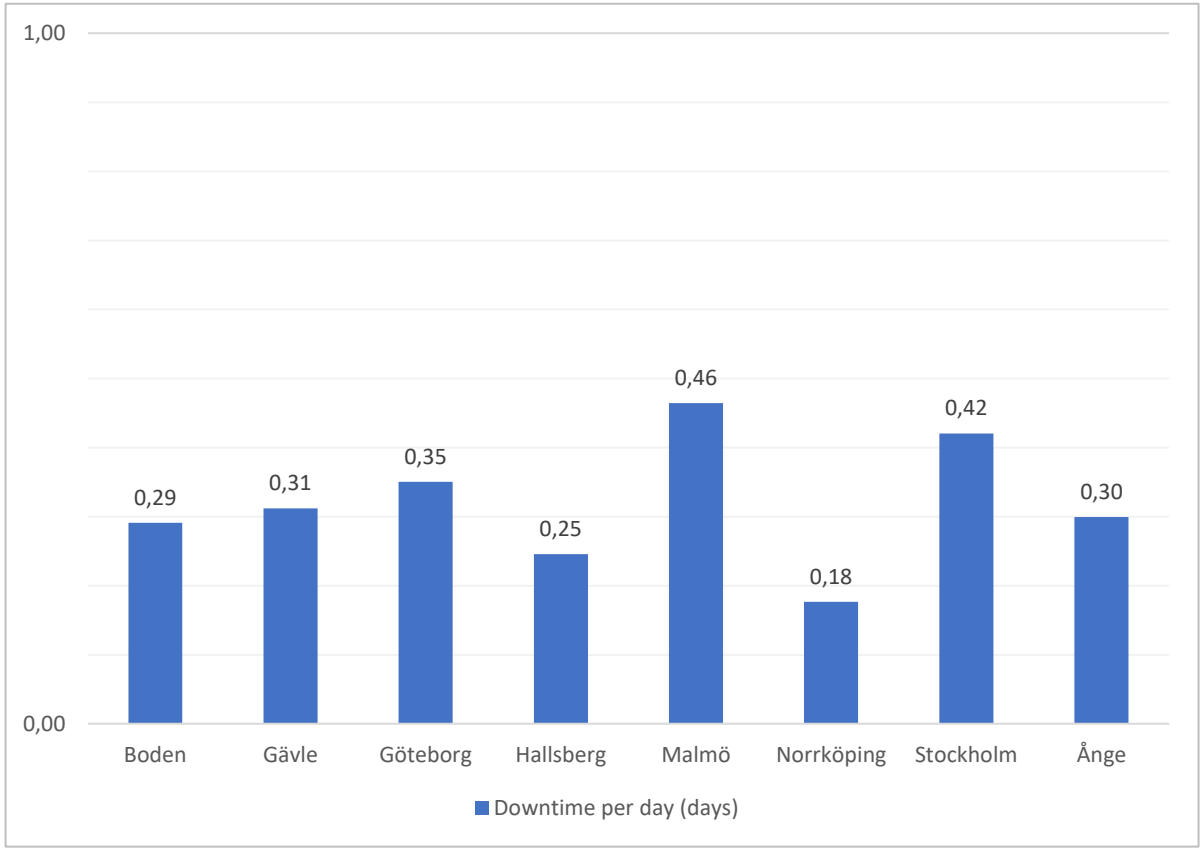
Variation across geographical location



- Longest downtime is in Malmo region @ approximately ½ day

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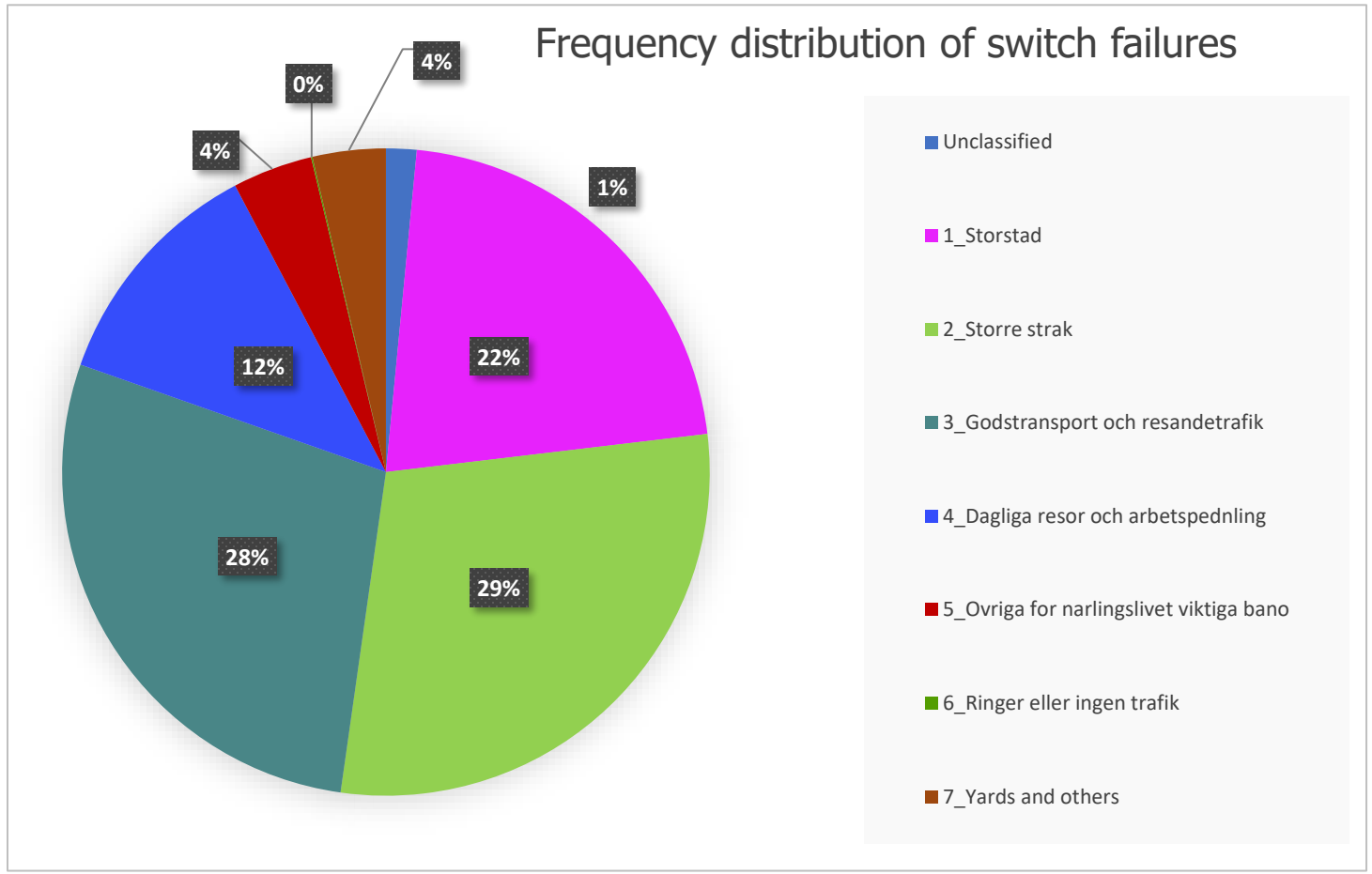
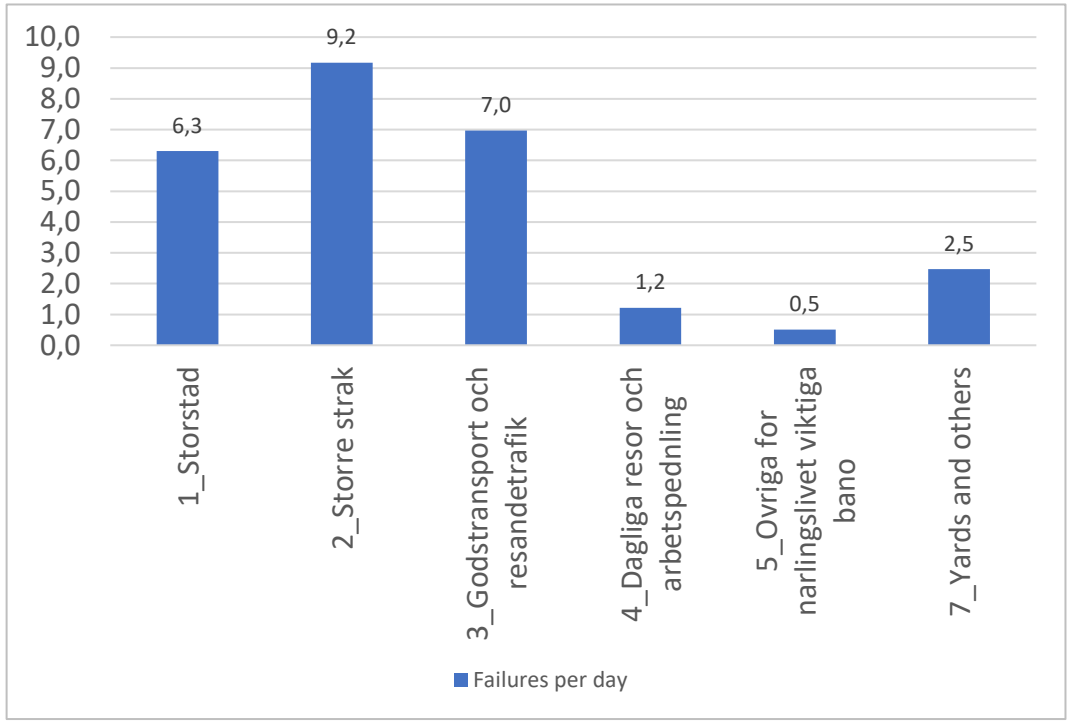
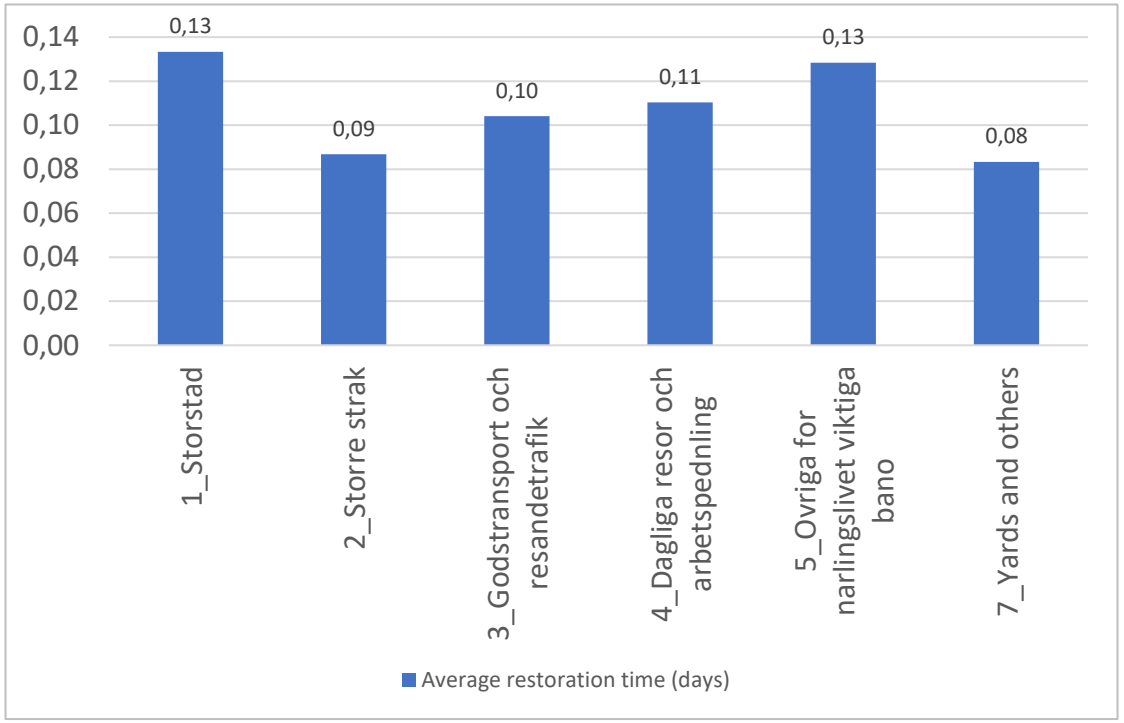
Variation across Track type



Source: Trafikverket, 2017, Uppdatering av bantyper

Variation across Track type





- Track type 2 & 3 register the largest number of failures per day
- Average restoration time is approx. 0.1 days (2,4hrs)

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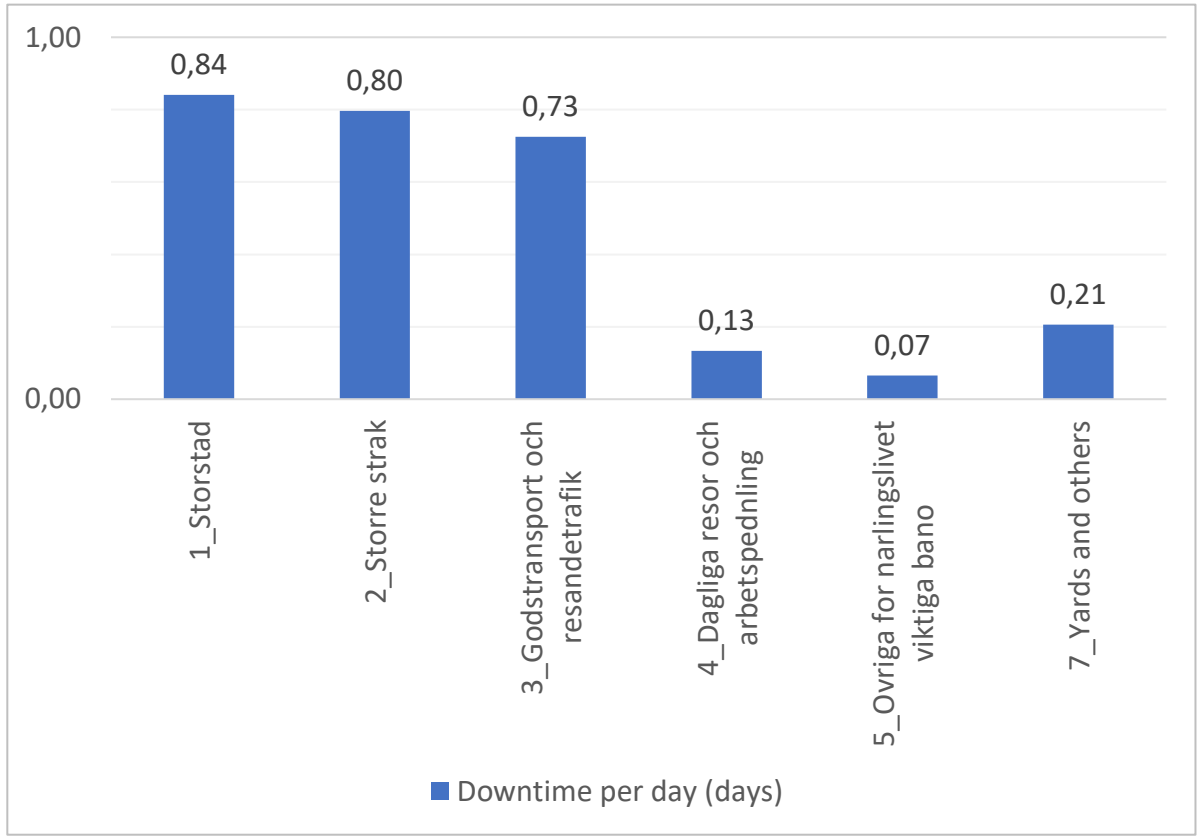
Variation across Track type



- City lines & Mixed Traffic lines register the highest downtimes

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Summary & Conclusion

- Research Question 1: How long does is it take to restore the railway network in the event of switch failures?

  - ✓ 2,4 hrs Restoration time; only 43% switch failures are restored within 2hrs
  - ✓ 1,3 hrs Repair time time; only 62% repairs completed within 2hrs
  - ✓ 0,5 hrs Response time; 84% switch failures responded to in 2hrs

This translates into average Downtime of 3days/day but may increase to 4.5 days/day on mixed traffic lines

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Summary & Conclusion

❑ Research Question 2: How does this restoration time vary across the network?

- ✓ Restoration time shows minor variations across seasons of the year, geographical location and nature of traffic of the line
- ✓ Repair & restoration times highest during the colder months of the year (Oct-Feb)
- ✓ Repair & restoration times highest on passenger lines & mixed traffic lines (Track types 1-3)
- ✓ Repair & restoration times highest in Goteborg, Malmo, Stockholm & Boden

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Discussion & Conclusion

- Next Steps
  - ✓ Qualitative studies to examine identified variations in restoration time
  - ✓ Model causal relationship between restoration time & delay taking into account small delays
  - ✓ Develop an emergency maintenance decision making objective model

- Limitations
  - ✓ Manually coded data
  - ✓ Outliers not considered

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Tack!