International Benchmark 2017-2021

Commerce & Development
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Contents

Management Summary - *1/5*

- This benchmark report compares the performance and productivity of NS with the five comparable passenger rail operators; DSB, Greater Anglia, NMBS, SBB and West Midlands Trains.
- The comparison period (2017-2021) included some pre-pandemic years, the pandemic in 2020 and 2021, which shows the first signs of recovery. This benchmark provides some insights in complexity of the underlying business logic of railways. It also shows the different ways in which railways and governments handled the impact of the COVID-19 pandemic.
- The differences in context and the harmonization of data can cause some "noise" in the comparisons. It is advisable to focus on comparing trends instead of absolute values. Positive trends can be pointers to best practices. Differences due to structural factors are indicated as much as possible.

Covid

- After the initial sharp decline of passenger demand in 2020, passenger numbers started to recover in 2021. In this benchmark, passenger numbers appear to have a strong relationship with government measures and operator choices. The most important factors are likely to include restrictions (e.g. lockdown measures), support for continuity of train service offering, train service reductions and measures to support passenger demand recovery (e.g. reduced fares).
- NS has faced a relatively sharp decline in passenger numbers and a slower than average demand recovery.
- Operators showed a wide variety of adaptations to train service offering. NS proved to be more flexible than other operators in adapting its service offering and production volume to changes in passenger demand (scaling down and up the number of seatkilometers), thus reducing the variable costs.
- KPIs with the most positive development during the pandemic were: customer satisfaction, punctuality (due to a drop in disturbances), seating availability. These KPIs are expected to decline with rising passenger numbers.
- KPIs with the most negative development were: relative energy usage and emissions, rolling stock and station utilisation, productivity, revenues and coverage of fixed costs. These KPIs will improve with rising passenger numbers.

Management Summary - *2/5*

Attractive product for passengers

- NS' overall customer satisfaction further improved and is now the highest of the peer group. On most aspects of customer satisfaction NS had an above average score.
- Most operators show rising customer satisfaction, both overall and on specific aspects. These improvements seem to be most strongly driven by the increasing punctuality.

- NS combined an above average level of customer satisfaction on seating availability with an above average occupation ratio for seating capacity, which is the result of both lower passenger numbers, but also the introduction of new planning tools. One operator uses a reservation system for intercity and regional trains, resulting in the highest customer satisfaction on seating capacity and the highest occupation ratio at the same time. Dutch domestic trains do not use a reservation system.
- All operators explore the possibilities of spreading the peaks in passenger demand. Some implemented demand management measures involving pricing incentives in coordination with transport authorities (overall higher fares with significant time depending discounts). NS has also developed a new fare structure proposal.

- Energy consumption and CO_2 emission per passengerkilometer increased in 2020 and 2021 due to the by the declining passenger numbers. NS has an above average energy efficiency and a negligible CO_2 emission when compared to the capacity offered.
- NS has an above average customer perception of security in trains and on stations. Operators with a higher customer perception of security might operate in a different societal context (e.g. lower overall crime numbers).
- The trends on security perception differ per country; most operators show a negative or neutral trend. Only one operator shows a consistent positive trend, probably due to factors from the wider societal context.

Management Summary - *3/5*

Punctuality and reliability

- During 2020 and 2021 most operators show a significant increase in punctuality, due to a lower number of disruptions during dwellings on stations. A lower number of trains during the COVID-19 pandemic, where applicable, also results in less knock-on delays. With rising passenger numbers, the punctuality of most operators shows some decline again.
- During this benchmarking period, NS consistently shows an above average and improving passenger punctuality and train punctuality while operating on one of the most densely utilized networks
- Some operators adhere to the practice of increasing buffer times in the timetable, improving punctuality at the expense of a higher travelling time for passengers and higher operational costs.
- Two operators have a well-developed policy in place to skip smaller stations in case of delays instead of cancelling trains. This is combined with rules that ensure that passengers at the skipped station do not have to wait overly long. This can lead to a reduced number of cancelled trains while having a positive effect on passenger punctuality. NS incidentally does this on high density lines, also focusing on passenger punctuality. The impact, effects and possibility to introduce this exception handling strategy in the Dutch context can be a topic for further study.

Capacity & utilisation

- Passengers per train, rolling stock utilisation and station utilisation declined (and partly recovered) with the declining (and recovering) passenger demand. As the train service offering of most operators varied less than the passenger demand, the network utilisation varied significantly less than the utilisation of stations and rolling stock.

Management Summary - *4/5*

Productivity

- All operators show a decrease of train driver and train guard productivity during 2020, partially restoring in 2021, due to the reduced demand, reduced train service offering and increased sick leave.
- Operators with a higher productivity of guards usually utilize advanced optimization tooling (e.g. scheduling software), a well optimized staff deployment model and/or operate with a lower-than-average number of guards per train.
- Until 2019 NS had a very high productivity of rolling stock. As with all other operators, during the COVID-19 period there was a strong reduction of rolling stock productivity, leading to a decrease of the coverage of fixed costs. NS has reduced train length more than other operators, resulting in lower variable costs. As long a passenger demand is reduced, rolling stock productivity will be lower than normal. Careful alignment of demand forecasting, demand management and long-term fleet planning can help to restore and increase rolling stock productivity.

Financial

- A comparison of financial performance includes all relevant financial flows; ticket revenues, public funding and track access charges. Dutch fare levels are above average, public funding and track access charges are below average. NS' overall revenues per passengerkilometer are below average, indicating relatively efficient operations.
- For NS the ticket revenues per passengerkilometer increased in 2020 and 2021, because the passenger demand declined, while the funding for the Student Card remained in place. With increasing passenger demand, the average ticket revenues per passengerkilometer will decrease again.
- All operators were compensated for revenue loss in 2020 and 2021, but different mechanisms and cost coverages were in place. Approaches included: transfer of the revenue risk to the government, full compensation for revenue loss, increasing debt and/or partial coverage of operational costs.
- Until 2019 NS was among the operators with the lowest net public funding. Since 2020 NS receives below average support for its revenue loss.

Management Summary - *5/5*

Operator and infrastructure manager

- NS consistently has the lowest number of significant accidents and a below average number of Signals Passing At Danger per trainkilometer of the peer group.
- All operators have developed joint season preparedness programs with their infrastructure managers. Climate change causes the focus to broaden, for example including summer heat problems and floodings. A joint ProRail-NS study could provide input for readiness for climate change.
- Most operators face increasing amounts of track works, resulting from more intensive use of the infrastructure and from system developments such as ERTMS. In some cases, the increased track works have a negative effect on the punctuality and reliability of passenger train services. Good practices include:
  - Making an integral trade-off between costs of the works and impact for passengers
  - Evaluating the impact for passengers (e.g. punctuality) and adapting the planning of track works using experience of past track works.

Contents

2.1 Introduction and objectives

Objectives: identify opportunities for improvement of the performance of NS

- Every three years NS carries out a benchmark project, in accordance with its 2015-2025 Transportation Contract (art. 26), to monitor its performance and to pursue continuous improvement. The peer group consists of at least four comparable operators. Topics cover the key performance areas of the Transportation Contract and the development of productivity.

- The benchmark encompasses data over a period of 5 years, to provide insight in trends and developments and to offer an overlapping continuity between the subsequent benchmarks.

- Results will be used to identify a realistic potential for improvement and best practices to contribute to NS' performance. Where applicable this will be input for NS' annual Transportation Plan or further research.

- The study encompasses a comparison between five European operators (DSB, Greater Anglia, NMBS, SBB, West Midlands Trains) and includes subjects like punctuality, safety, costs, sustainability and productivity.

- As KPI data and financial data is sensitive for most operators, there are confidentiality arrangements with the participating operators involving anonymisation and ranking.
  - All KPI and financial data in this benchmark will be presented anonymously and ranked per comparison. Therefore, the operator codes change per comparison to prevent identification of individual operators.
  - All KPI and financial data will be presented as indices (not absolute numbers), with 100 as the average for data of 2019. Where available data for 2019 is incomplete, the year with the most data available will be used for the index (this will be stated where applicable).

2.2 Context, data and analysis process

Challenging process to collect, compare and analyse international rail data

- The peer group consists of train operators from Belgium, Denmark, Switzerland and the United Kingdom. The peer group is largely the same as the peer groups of earlier benchmarks of NS to ensure continuity and long-term perspective.

- NS used multiple sources for this benchmarking study:
  - Publicly available information (annual reports, internet, statistical bureaus, sector reports, etc.);
  - Data from international benchmark platforms and working groups that NS participates in;
  - Bilaterally exchanged information from the peers (covering 2017 - 2021).

- The data collection and analysis process has proven to be quite challenging:
  - Not all peers have all requested data for the requested years available or use different definitions
  - During 2020 and 2021 many indicators were not measured or measured differently. This results in a number of analyses with data missing for some of the peers or years.
  - Differences in context; in cases where comparisons require caution, because of differences in definitions or context, this is mentioned in the texts.

- All companies were consulted to verify and complete the data, evaluate trends and exchange best practices.

- Financial data is harmonized for exchange rates and purchasing power parity levels (PPP).

- As harmonization of customer satisfaction scores and some other KPIs adds some “noise” it is advisable to focus on comparing trends instead of absolute values

- Following a confidentiality protocol, all data in graphs is anonymized, indexed and ranked. In most cases 2019 is used as the index year. Where this was not available, 2018 is chosen as the index year (as indicated in the graphs).

- This benchmark study is reviewed by KiM Netherlands Institute for Transport Policy Analysis (KiM).

Contents

3.1 Peer group criteria and choice

The peer group consists of operators that run medium-sized, high-density operations

Criteria

1. As many participants as possible from previous international benchmarking studies by NS to establish a long-term perspective with time series of data
2. Comparability and learning potential:
   a. Operations: commuter / regional transport, travel distance, traffic density, average speed, size
   b. Infrastructure: network lay-out, potential weather / winter influences, intensive use of network; multiple operators on network
3. Cooperation of peer group / availability of data:
   a. Willingness to participate (market / competition issues, confidentiality conditions). This becomes increasingly an issue with the liberalization of the European Re
   b. Existing cooperation in other international working groups and/or benchmarking platforms

	Train operators
	NS
	NMBS
	DSB
	Greater Anglia West Midlands Trains
	SBB

3.1 Peer group criteria and choice

Some key figures of the peer group

The table summarizes some structural characteristics of operating environment of the peers[1]. Differences in these parameters have significant impact on the performance of the peers.

						
	**Passenger operator(s) in peer group**	NS	DSB	GA, WMT[2]	SBB	NMBS
	Infrastructure manager	ProRail	Bane-danmark	Network Rail	SBB	Infrabel
	Network (routekm) – in scope	2 204	1 332	511 and 900	3 265	3 612
	**Area – land (km²)**	33 893	42 434	241 930	39 997	30 278
	Population (mln)	17.46	5.95	68.14	8.56	11.90
	Population density (inh./km¹)	515	140	282	214	393
Rail ratio's	**Routekm / 1000 km² land**	90	61	70	130	119
	Inhabitants / km network	5 715	2 293	4 300	1 646	3 306
	Passengerkm (train) / km² (3)	301	99	162	356	230
	Pass.km (train) / inhabitant (3)	584	703	574	1 661	585

Most countries have one major passenger rail operator and infrastructure manager, with UK as a notable exception. The network size in the table above refers to part of the network that is operated by the operator in the peer group. All passengerkm numbers are national (Eurostat / KiM), except in the cases of SBB and NMBS, where the passengerkilometers of only that operator are given.

1 Sources: Eurostat 2021, CIA Factbook, PRIME 2021, CBS
2 GA = Greater Anglia; WMT = West Midland Trains
3 Passengerkm: 2019

3.2 Organization and market regime

Peer group: a mix of operators with tendered and directly awarded transportation contracts

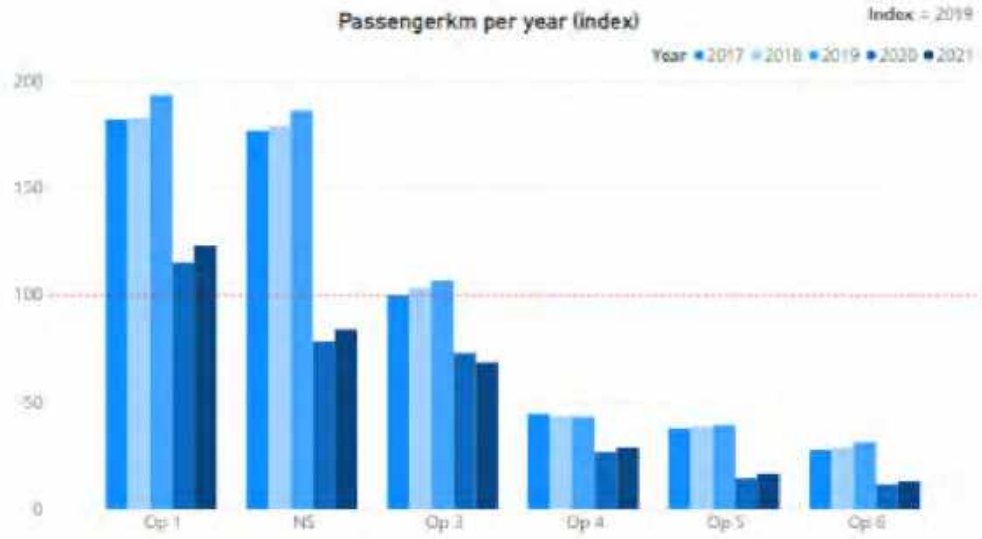
- The peers operate in different market environments. Main difference: DSB, NMBS, NS and SBB have directly awarded transportation contracts while Greater Anglia and West Midlands Trains first operated tendered contracts, but later Emergency Recovery Measure Agreements. Open access operation may be formally applicable but is very limited or absent in practice.
- Greater Anglia and West Midlands trains share a significant part of the network with other operators, introducing more coordination with multiple other passenger operators. The operation of the other peers involves significantly less interaction with other operators on the same network.
- The operators in the peer group are also responsible for station management. The exact implementation differs with the network, station and market characteristics.
- SBB and other Swiss rail operators have both infrastructure management and operations in holding structures. All other countries in the peer group have infrastructure management and operations in different organizations (the infrastructure manager being a company or a government organization).

Market segment					
HS passengers	Open access	Open access	Open access	Open access	Open access
IC passengers	PSC direct award	PSC direct award	PSC direct award	PSC tendered	PSC direct award
Commuter trains	PSC direct award	PSC direct award	PSC direct award	PSC tendered	PSC direct award
Regional passengers	PSC tendered	PSC direct award	PSC direct award & tendered	PSC tendered	PSC direct award
Freight	Open access	Open access	Open access	Open access	Open access

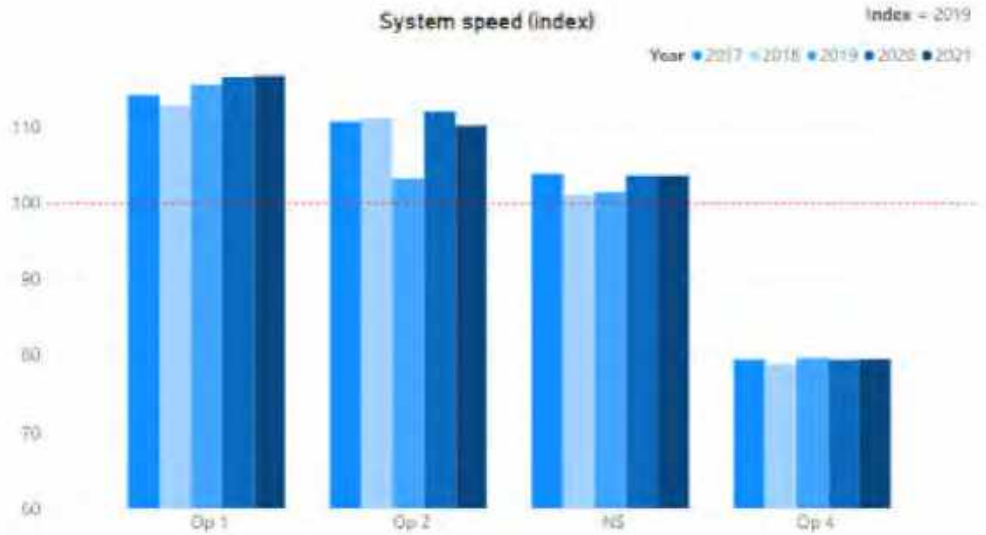
PSC: public service contract

3.3 Characteristics and key figures

NS is among the largest operators of the peer group. Passengers have above average trip lengths.

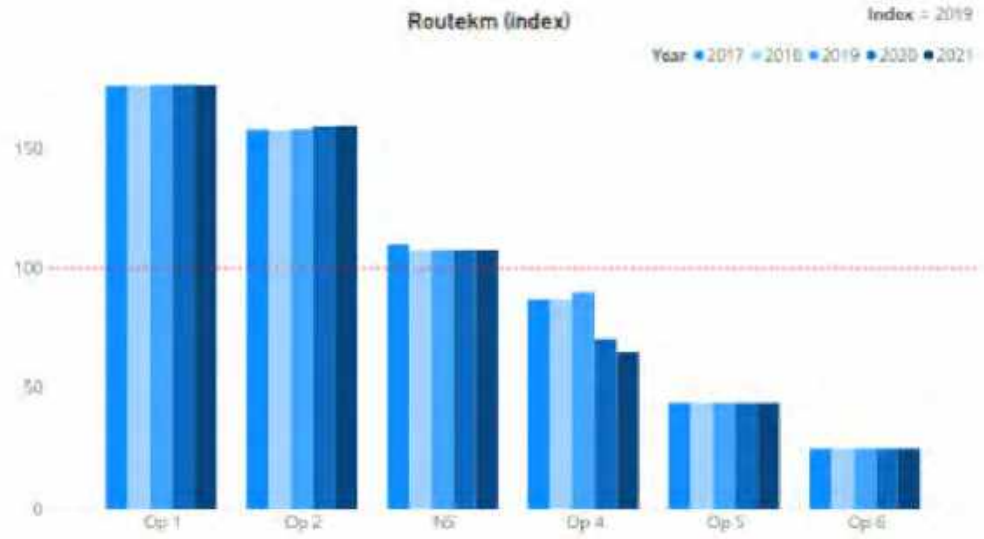


- NS is one of the largest operators of the peer group, with in 2019 a passenger volume of 86% above the average and in 2021 still 51% above average.
- The average trip length of NS passengers is slightly above the average of the peer group.
- The system speed is around the average of the peer group. Two operators have more long-distance trains with a lower number of stops and a higher average speed. Not all operators report system speed.

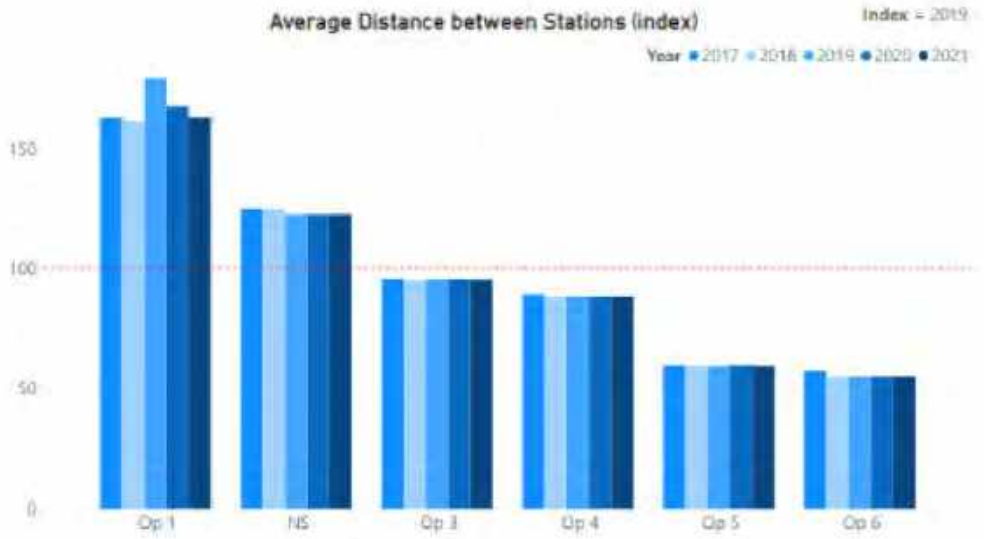


3.3 Characteristics and key figures

NS operates on one of the most densely utilised networks. Distance between stations is above average.



- The size of the network that NS operates is above the average of the peer group.
- NS operates a much higher volume of passenger trains on its network resulting in one of the most intensely utilized networks. Utilisation is around 40% more trainkilometers per routekilometer than the average of the peer group.
- NS' distance between stations is above average. This is mainly caused by the fact that some regional lines are not operated by NS anymore.



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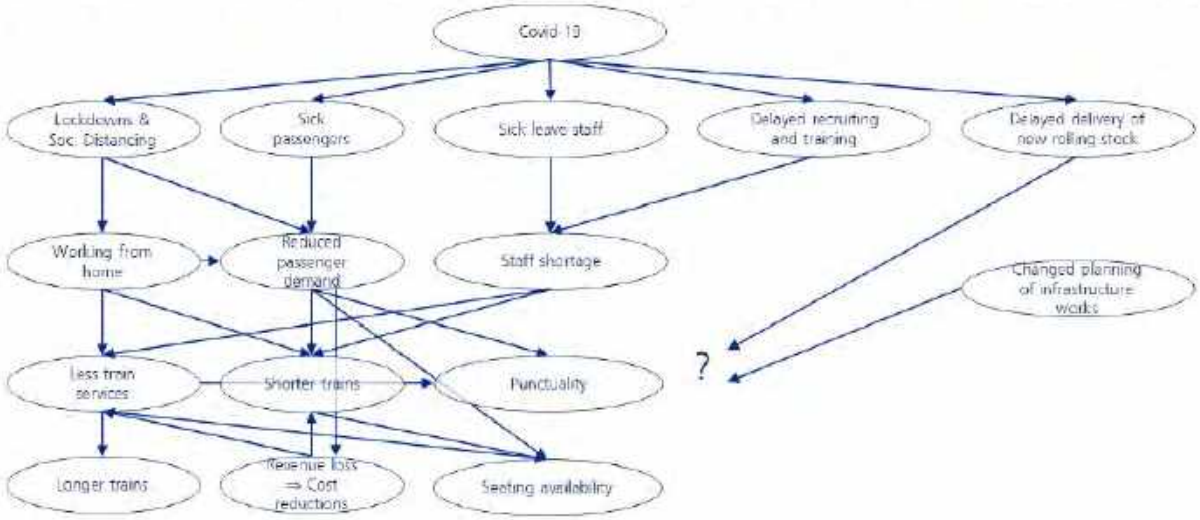
4. Impact of COVID-19 – *General*

COVID-19 had impact on many factors in the complex railway system; main elements in this chapter.

- The railway system is a complex system of factors and actors with interdependencies between passengers, staff, rolling stock, infrastructure, processes, government, stakeholders, etc.
- The COVID-19 pandemic impacted a wide range of these factors with various effects on the service quality, performance, productivity, costs and revenues. The figure below gives an indication of some main interactions between a part of these factors.
- This chapter will mainly cover changes in passenger demand, train service supply and the interplay between operators and governments. Specific performance issues will be covered in the later chapters of this report.
- The COVID-19 crisis resulted in both temporary and long-lasting changes in passenger demand. NS and TU Delft conducted a longitudinal study, that indicates longer term changes in demand.[1]
  - Temporary changes are mostly a result from compulsory working and studying from home.
  - Structural changes include different travel patterns over hours, days and weeks, due to (partially) working and studying from home. Also, some passengers made a permanent shift to individual transport modes. All operators in the peer group are developing initiatives to adapt to the changed demand.



1. http://smartptlab.tudelft.nl/images//media_Niels/22020912_Infographic_Gedrag_treinreiziger_na_COVID_Definitief_EN.pdf

4.1 Impact of COVID-19 – *Passenger demand*

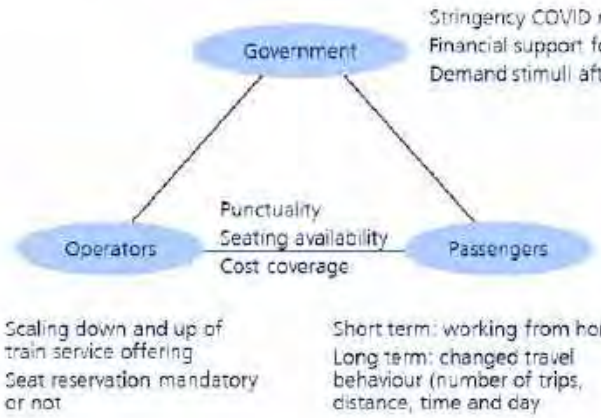
NS' passenger demand reduced more than average, NS demand recovery is below average
Recovery measures typically involve subsidized fare reductions and increased train service offerings

- In 2020 NS passenger demand dropped by around 60%. This makes NS one of the three operators with the highest reduction of passenger demand. There is some uncertainty in the passenger numbers, as one operator stated problems measuring and calculating the number of actual passengers during the pandemic.
- In the case of NS, the average trip length increased after the start of COVID-19; a lower number of passengers who are making longer trips. This corresponds with a decrease of typical commuter trips in the Netherlands [1]. Three other operators show a similar pattern, the others see typically shorter trips which may reflect that commuters make longer trips there .
- In 2021 NS faced a recovery of passenger demand that was significantly below average. Other operators show a stronger recovery of passenger demand, presumably driven by:
  - less stringent government restrictions during the COVID-19 pandemic
  - Less train service reduction during 2020 and 2021 and faster and/or larger increase of the train service offering
  - subsidized fare reductions and/or postponed price increases for inflation ("volume first, yield later")
  - a shift towards yield management ticket types

1: http://smartptlab.tudelft.nl/images//media_Niels/22020912_Infographic_Gedrag_treinreiziger_na_COVID_Definitief_EN.pdf

4.1 Impact of COVID-19 – *overview of demand impacting factors*

Government measures, reductions of the train service offering and the structure of passenger demand were the main factors driving the loss of passenger demand



- When comparing the measures and effects during COVID-19 there are significant differences in choices of governments, operators, infrastructure managers and passengers.
- The matrix below slows correlations between the passenger demand and a selection of parameters. As the number of operators, years and variables is limited, one should be cautious interpretating these relationships:
  - Passenger demand recovery in 2021 was slower in cases with more stringent COVID measures and a stronger reduction of the train service offering during 2020 and 2021.
  - In cases of a higher modal share and a higher cost coverage of the train loss of modal share and cost coverage was higher.
  - In cases with more stringent COVID-19 measures, the governments provided a higher level of financial support to the operators
  - Operators that maintained a high train service offering (trainkm) generally reduced train length to match the lower demand.
  - Cost coverage appears to be closely related to traffic density

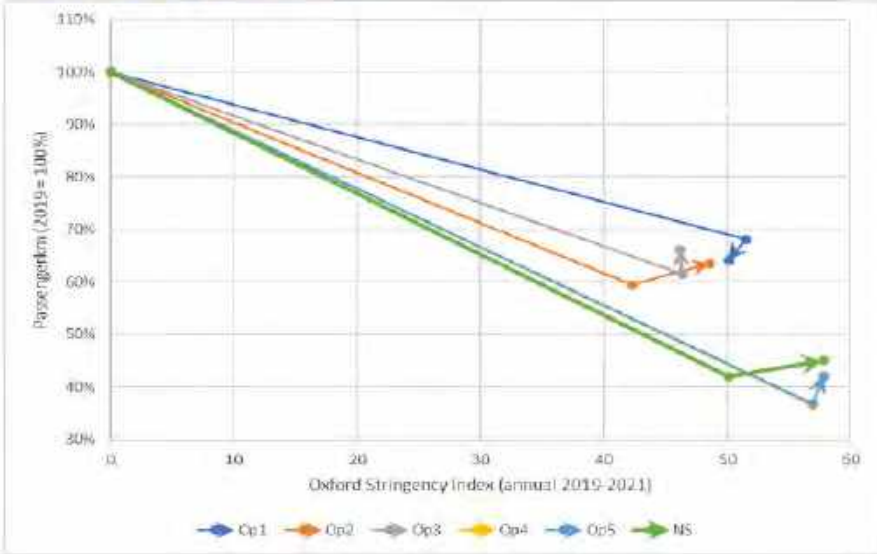
	Density traffic 2019	Modal share 2019	Loss of modal share during COVID	Cost coverage 2019	COVID support government	Stringency COVID measures	Train service offering during COVID (trainkm)	Seats / train during COVID	Passenger demand recovery 2021
Density traffic 2019	1,00								
Modal share 2019	0,36	1,00							
Loss of modal share during COVID	-0,47	-0,92	1,00						
Cost coverage 2019	0,83	0,19	-0,47	1,00					
COVID support government	0,24	-0,66	0,45	0,48	1,00				
Stringency COVID measures	0,35	-0,46	0,16	0,61	0,89	1,00			
Train service offering during COVID (trainkm)	0,13	0,32	0,02	-0,25	-0,39	-0,70	1,00		
Seats / train during COVID	-0,35	-0,28	-0,02	0,22	0,41	0,51	-0,76	1,00	
Passenger demand recovery 2021	-0,57	0,20	0,13	-0,77	-0,69	-0,92	0,70	-0,39	1,00

4.1 Impact of COVID-19 – *Passenger demand*

Passenger demand in a country follows (inversely) government restrictions.
Comparing across countries other factors have to be taken into account.

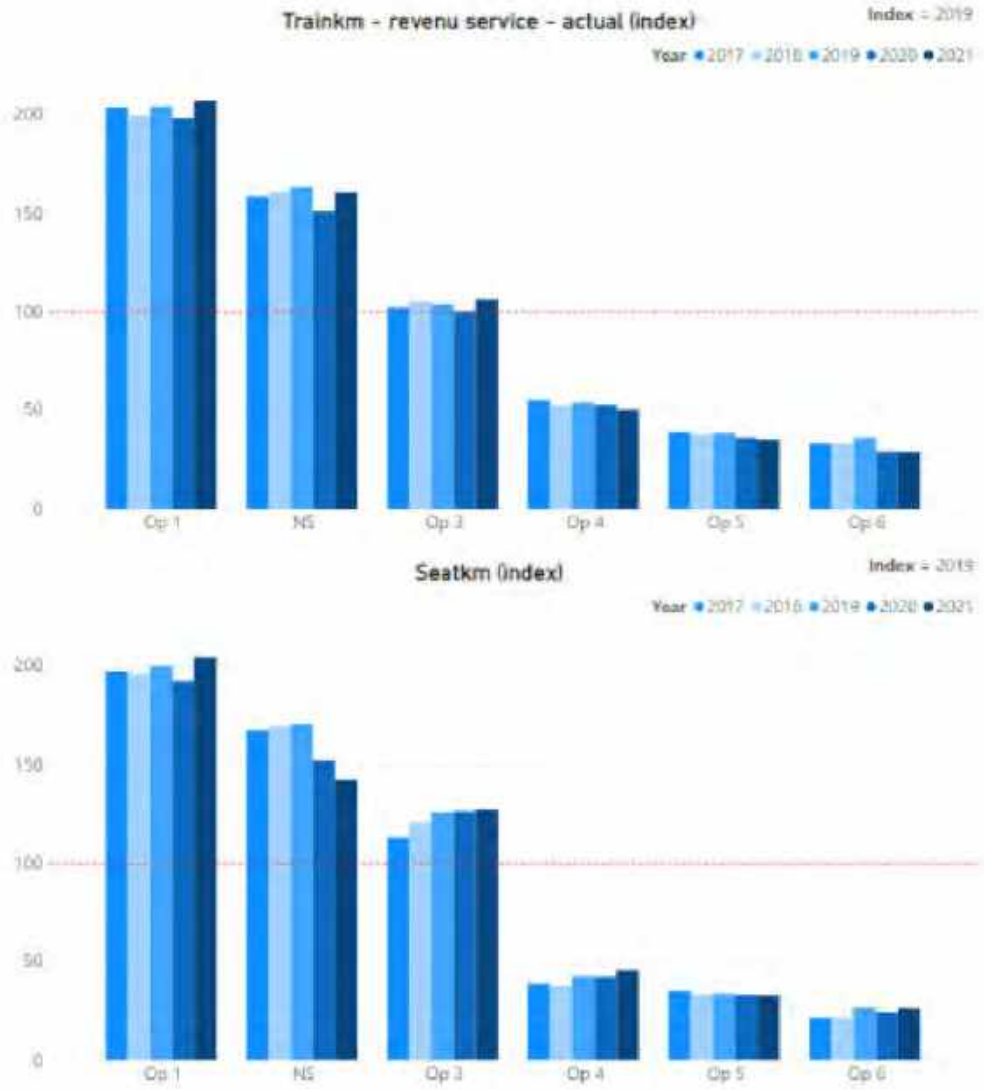
	Oxford Stringency Index			
	2020	2021	2022	Avg 20-22
Belgium	52	50	18	40
Denmark	46	46	13	35
Netherlands	50	58	21	43
Switzerland	42	49	14	35
UK	57	58	14	43

- The Oxford Stringency Index indicates government measures in the COVID-19 pandemic period, e.g. lock downs, facemasks, etc. In the Netherlands the stringency was above the average of the peer group.
- There appears to be a strong relation between the stringency and the evolution of the passenger numbers. It seems that passengers were more reluctant to travel in 2020, which can explain the passengerkm growth in 2021 for some companies.
- When comparing among countries, more factors come into play, such as reduced fares after the height of the COVID-19 pandemic.



4.2 Impact of COVID-19 – *Train service supply*

NS had an average reduction of the train service offering in coordination with the Dutch government.



- Operators show significant differences in adjusting the train service offering during and after the COVID-19 pandemic, mainly relating to government policy and financial support.
- During the COVID-19 pandemic the following approaches were mentioned:
  - Slightly less trains, far less seats (vehicles)
  - Significantly less trains, but longer trains (social distancing)
  - Keeping the operation as much unaltered as possible ("changes are a logistical nightmare")
  - Mandatory use of a reservation system
- After the height of the COVID-19 pandemic, restrictions were lifted. The following approaches were mentioned:
  - Focus on fast demand recovery, even if this is costly; more trains, lower fares.
  - Focus on cost reduction and adapting to the decreased demand level; less trains, shorter trains.

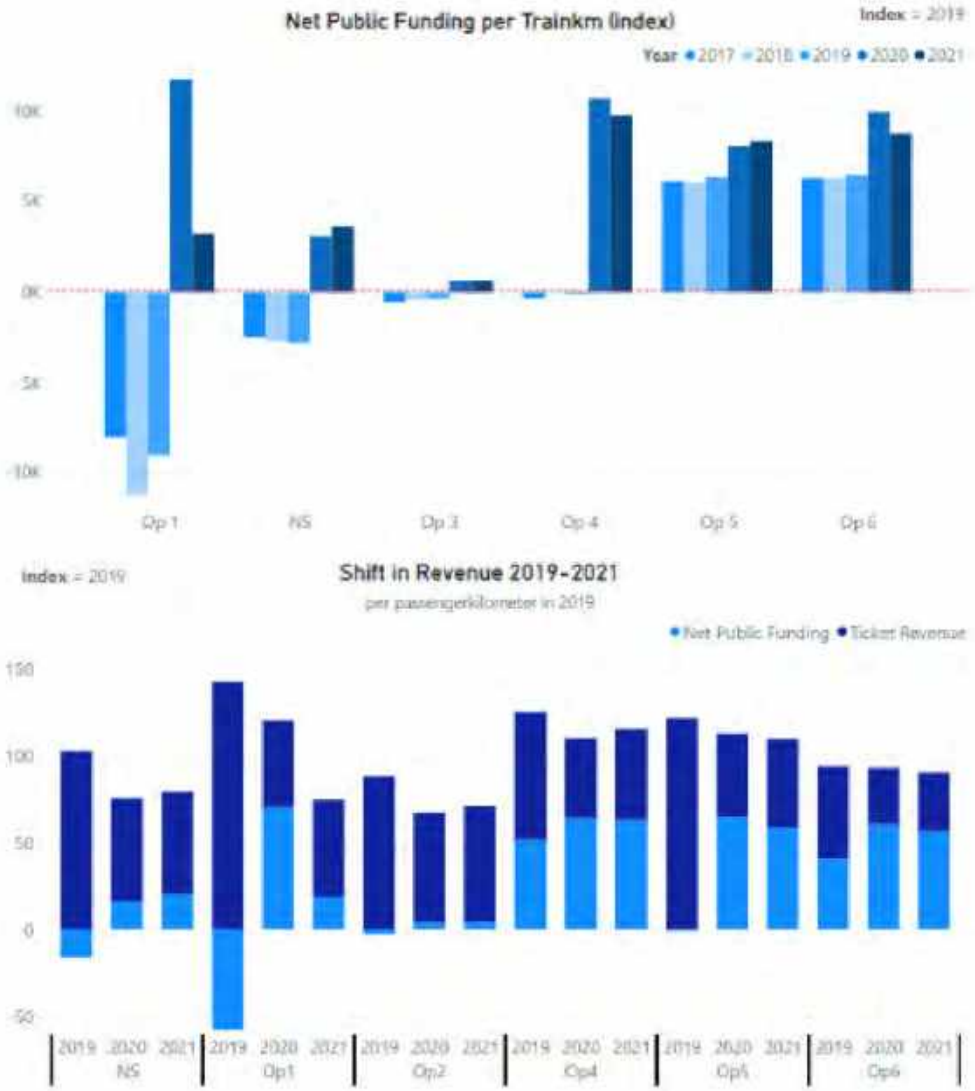
4.2 Impact of COVID-19 – *Train service offering*

NS train service offering reflects the changes in demand and demonstrates a strong cost focus

- During 2020 NS initially significantly reduced the train service offering, as passenger demand decreased by measures aiming to reduce the spread of COVID-19. This reduction was more than the average operator in the peer group.
- In the second part of 2020 and 2021 NS increased the train service offering above the average of the peer group.
- In 2020 and 2021 NS reduced the number of seat-kilometers more than any other operator. This shows flexibility in matching supply and demand and a strong cost focus.

4.3 Impact of COVID-19 - *Financial*

NS was one of the operators with the largest decrease of cost coverage of the peer group. Goverment support was below the average of the peer group. Operators with lower support increased debt.



- Governments applied a variety of financial arrangements during 2020 and 2021, such as:
  - Transfer of the revenues from the operator to the government and covering allowable operational costs of the operator (emergency contracts and gross contracts).
  - Covering all costs that were not covered by ticket revenues (net contracts).
  - Covering a part of the costs that were not covered by ticket revenues (COVID-19 support).
- Until 2019 NS was among the operators with the highest cost coverage from ticket revenues and the lowest net public funding (subsidy – concession fee – track access charges).
- As NS faced one of the largest relative decreases in passengerkilometers, this business model was seriously impacted.
- During 2020 and 2021 NS received a below average level of support for its revenue loss. Operators with a lower level of public funding (such as NS) had to increase their debt.

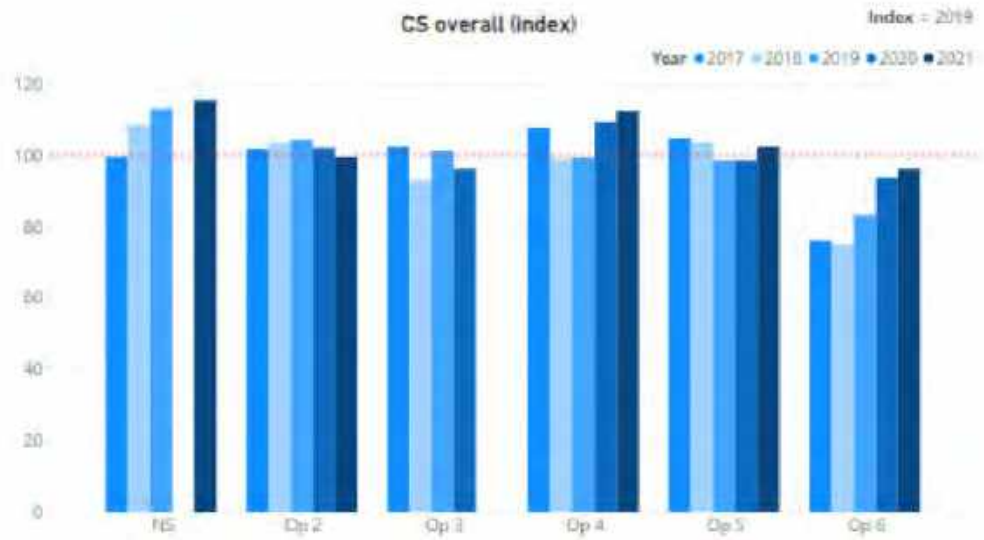
4.4 Impact of COVID-19 – *Evaluation and practices*

- The COVID-19 pandemic impacted the railway systems in many aspects and factors, reflecting in most KPIs, productivity and financial performance.
- Different in adapting the train service offering were mentioned, such as: no significant changes, less but longer trains, less trains and less seats and/or mandatory seat reservations.
- NS initially reduced the train service offering more than other operators. Later the train services were restored but with less seats per train, reflecting the reduced passenger demand. NS showed an above average level of flexibility in adapting supply to demand and reduce (variable) costs.
- All operators show a significant revenue loss while having limited possibilities to reduce costs (staff and rolling stock).
- Governments and operators applied different financial arrangements during 2020 and 2021, including transfer of the revenue risk to the government, full or partial cost coverage and partial cost support and increasing operator debt.
- Many governments and operators promoted recovery of passenger demand after the pandemic by fare reductions or fare caps, demand management measures and/or increasing the train service offering. In the Netherlands these measures were relatively limited.

Contents

5.1 Attractive Product for Passengers – *Customer satisfaction*

NS maintained a high and increasing customer satisfaction, but also an above average complaint rate

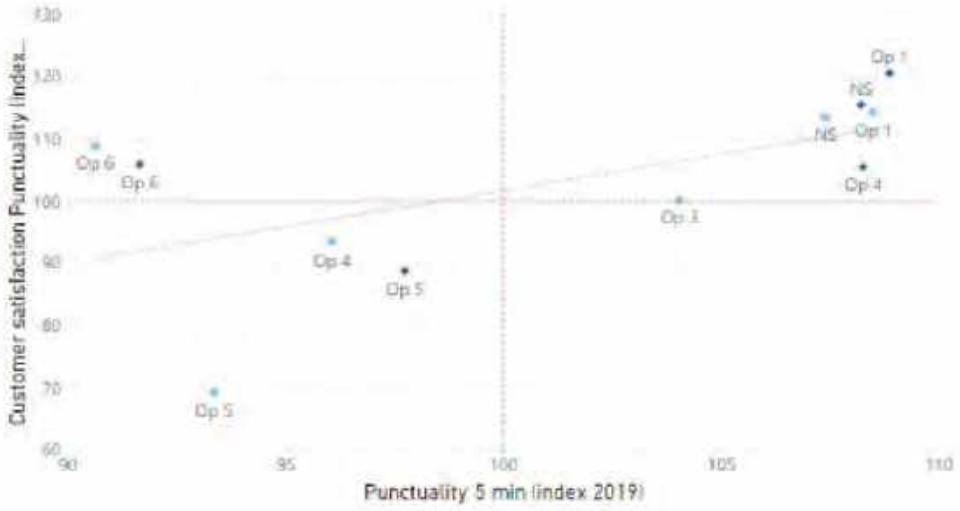


- In 2021 NS had the highest overall customer satisfaction of the peer group. As the customer satisfaction was measured in 2021 only during a limited period, there is some margin of uncertainty in this number.
- Most operators show an increase of the customer satisfaction in 2020 and 2021, citing an appreciation of the continuity and performance of the train services in times of crisis. The change of the mix of passengers (commuter, student, business, leisure) can also have impact on the customer satisfaction.

- Like in former benchmark projects, NS passengers have a relatively high complaint rate. In 2020 most complaints and customer service contacts were COVID-19 related (season tickets, restrictions, passenger behaviour and enforcement).
- Complaint rate however does not show a clear relationship with the customer satisfaction. This can be caused by:
  - cultural differences in making complaints and filling out customer satisfaction surveys.
  - differences in effort for passengers that is needed to register a complaint

5.1 Attractive Product for Passengers – *Customer satisfaction on punctuality*

The customer satisfaction on punctuality has a major impact on the overall customer satisfaction.

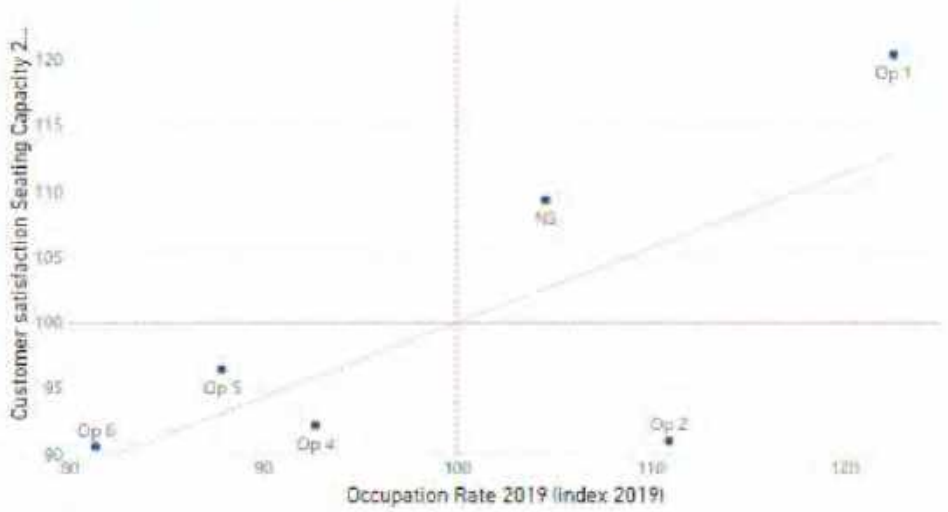


- Most operators show the importance of the customer satisfaction on punctuality for the overall customer satisfaction. These insights can be seen in numerous statistical analyses.
- A simple XY plot of the overall customer satisfaction and the customer satisfaction on punctuality already indicates the importance of punctuality for overall customer satisfaction.

- Generally, there is also some relation between customer satisfaction on punctuality and the actual punctuality.
- When trains run a higher frequency the impact of dis-punctuality (or cancellations) is less severe for passengers. In these cases, the impact of dis-punctuality on the customer satisfaction can be lower.
- When passengers make longer trips (with connections) the impact of train punctuality on customer satisfaction can be higher. However, the level of expectation of passengers regarding punctuality is also an important factor in customer satisfaction.

5.1 Attractive Product for Passengers – *Seating capacity*

NS has an above average customer satisfaction, partly driven by data-driven planning.
The highest customer satisfaction and seat occupancy is realised using a reservation system.

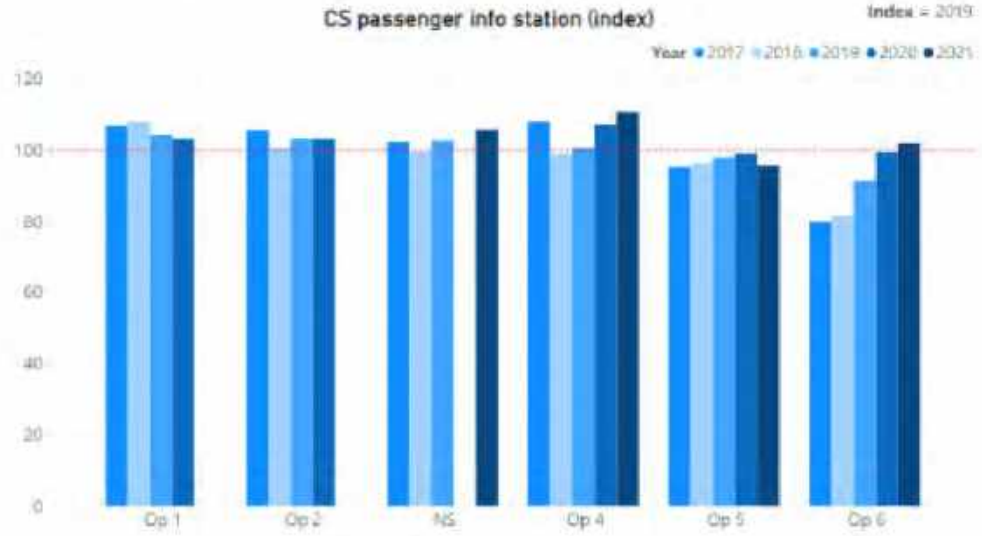


- Like most operators NS' customer satisfaction on seating availability increased during 2020 and 2021
- The operator with the highest customer satisfaction uses a reservation system on most of its trains.
- NS also has a relatively high customer satisfaction. Over the last years improvements were made by introducing more data driven management of seating capacity based on "passenger standing minutes"

- The operator with the highest customer satisfaction on seating availability also has a very high occupation ratio of seats. This is probably related to a reservation system. After the mandatory use during the pandemic, the voluntary use of reservation stayed high.
- During the COVID-19 pandemic this reservation system was mandatory and free of charge. After the height of the pandemic many passengers still chose to use reservations.
- This indicates the advantages of reservation systems for the passenger (securing a seat) and the operator (lower unit costs).

5.1 Attractive Product for Passengers – *Passenger information*

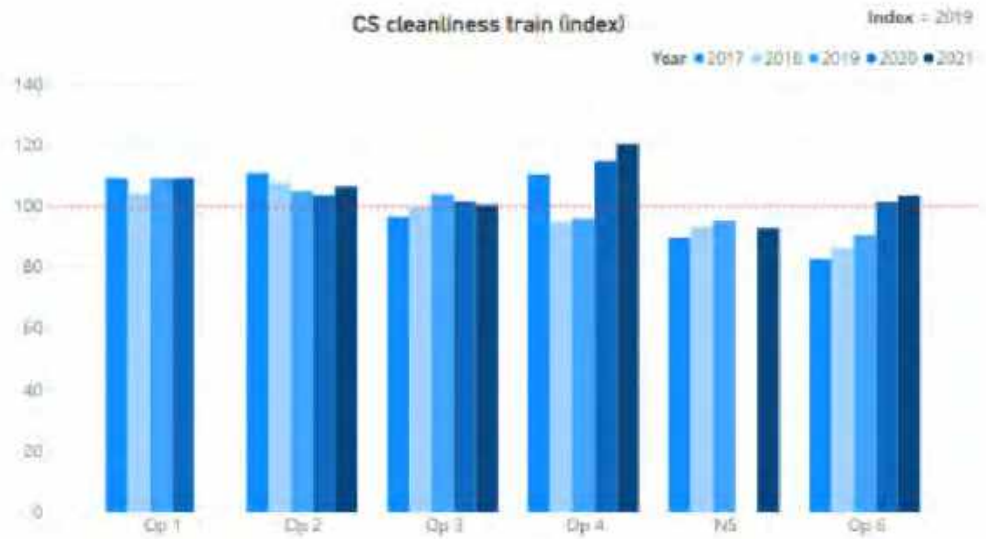
NS has an average and stable customer satisfaction on passenger information



- NS has an average and stable customer satisfaction on both passenger information in the train and on the station.
- Operators that show an increasing customer satisfaction on passenger information are investing in digitalization (e.g. new rolling stock with advanced passenger information systems).
- Op1 of the info disruptions graph (and the associated infrastructure manager) invested in providing fast and personalized travel information during disruptions after concluding it was a key factor for customers.

5.1 Attractive Product for Passengers – *Cleanliness*

NS' customer satisfaction on cleanliness of train interiors is slightly below average and stable



- All operators dedicated more attention to cleaning during the COVID-19 pandemic, resulting in higher customer satisfaction.
- The customer satisfaction about cleanliness of train interiors at NS is below average. The extra efforts did not result in a higher appreciation by the passengers.
- These results are in line with outcomes of earlier benchmarks. As mentioned in the 2019 benchmark, high expectations of Dutch passengers and a critical response style (cultural factors) play important roles in customer satisfaction scores.
- As in 2021 the customer satisfaction of NS was measured only during a limited period, there is some margin of uncertainty in this number.
- Operators also cite active communication about cleanliness and visible cleaning activities as factors that contribute positively to customer satisfaction.

- NS also used to measure cleanliness of stations, but this is not included in the national OV Klantbarometer (Public Transport Customer Barometer). Therefore, cleanliness of stations is not included in this benchmark anymore.

5.1 Attractive Product for Passengers – *Frequency and connections*

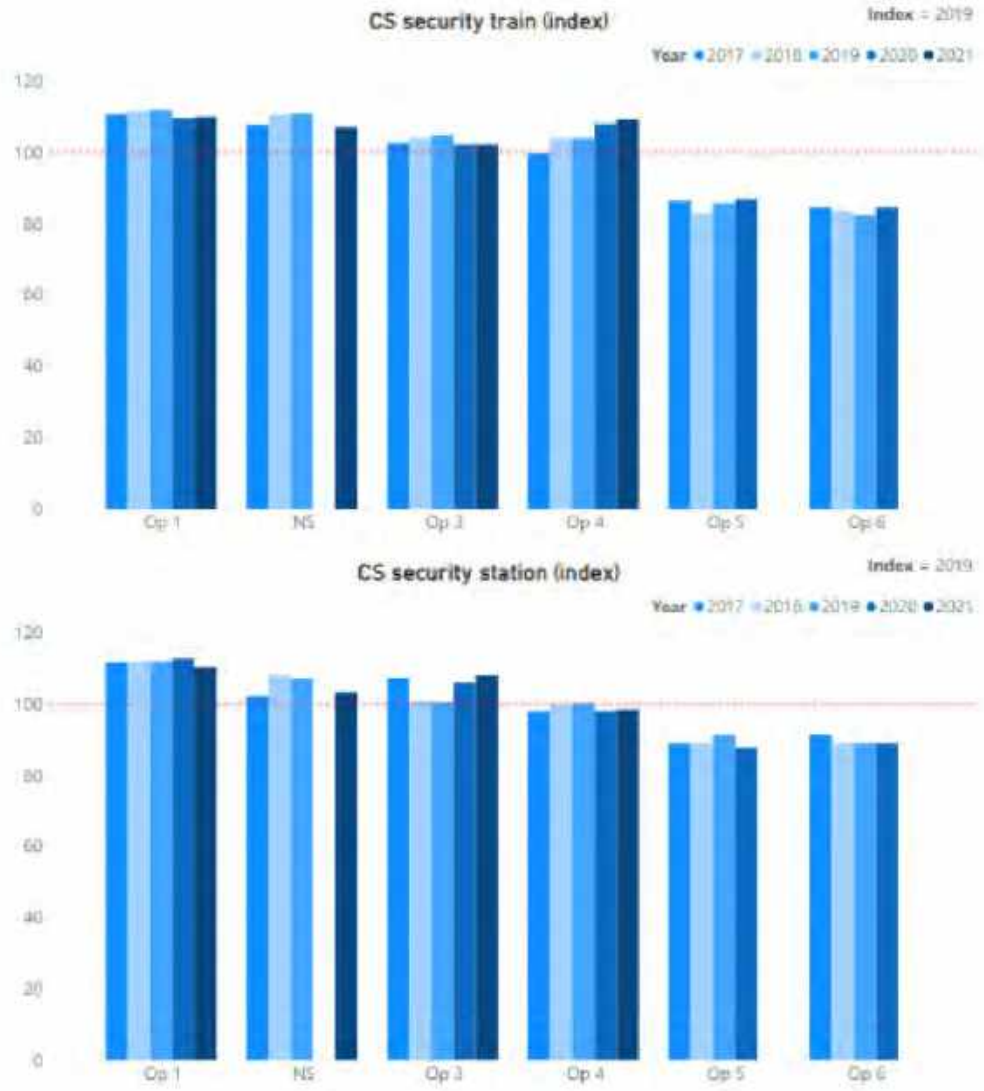
High customer satisfaction on frequencies and connections reflect the integrated train service offerings, even in times of the COVID-19 pandemic.

- NS' customer satisfaction about train service frequency is around average and rather stable.
- Operators that show an increase of the customer satisfaction in 2020 and 2021 are citing an appreciation of the continuity of the train services in times of crisis. Reductions in train services result in lower customer satisfaction.
- As there was some data missing for 2019, in the graphs 2018 has been chosen as the index year.

- NS' customer satisfaction on the connections is around the average of the peer group. As passengers dislike transfers during trips, NS timetable design has a strong focus on providing direct routes.
- Other operators that show increases also invested in additional train service offering based on an integrated timetable (re)design.

5.2 Security – *Customer satisfaction*

NS has a higher than average customer satisfaction on security. Trends seem to reflect wider societal perceptions of security.

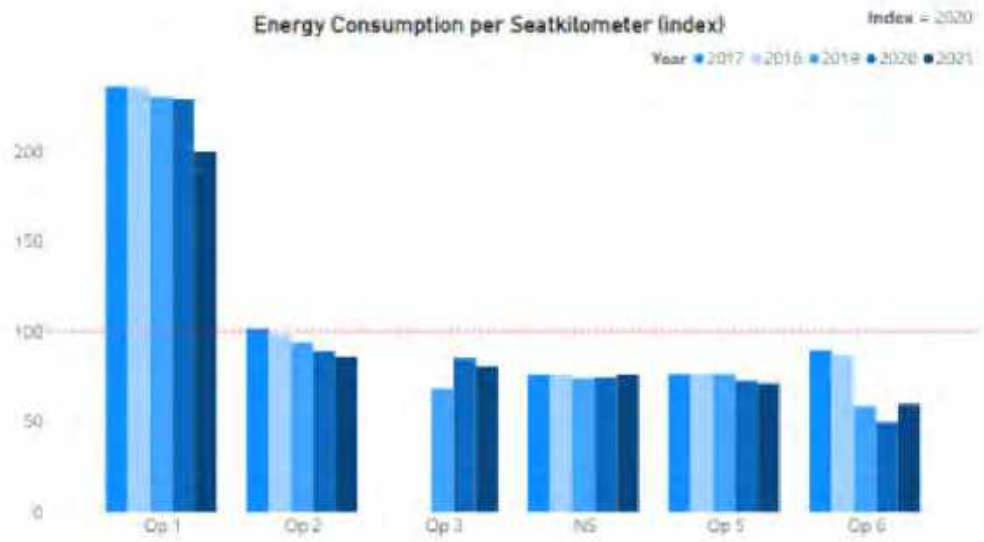


- Customer perception of security in trains and on stations is generally high.
- NS has an above average customer perception of security in trains and on stations.
- The trends on security perception differ per country; most operators show a negative or neutral trend. Only one operator shows a consistent positive trend.
- Overall, there is a correlation between security perception and the number of guards per train. However, the best performing operator is an exception with a below average number of guards per train. Here it seems more a reflection of a wider societal differences between countries.
- Data on security incidents is difficult to compare, because of the variety in definitions and logging practices. Therefore, it is not possible to relate customer satisfaction and numbers of incidents in this benchmark.
- Customer perception of security on stations is generally lower than that of security in trains.
- The ranking and trends among the operators is similar, probably reflecting more overall trends in societal perceptions of security per country.

5.3 Sustainability – *Energy usage*

NS energy efficiency per seatkm above average and stable, decline per passengerkm due to lower demand

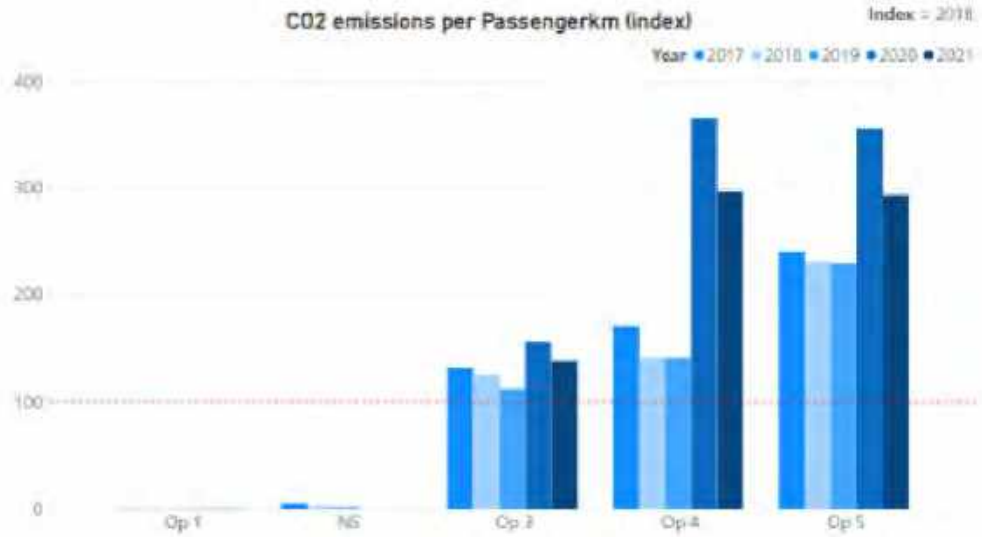
- During 2020 and 2021 the energy usage per passengerkilometer increased for all operators.
- This declining energy efficiency due to the combination of a fallen passenger demand while the train service offering was largely maintained.
- Energy efficiency can be expected to recover when passenger demand increases again.



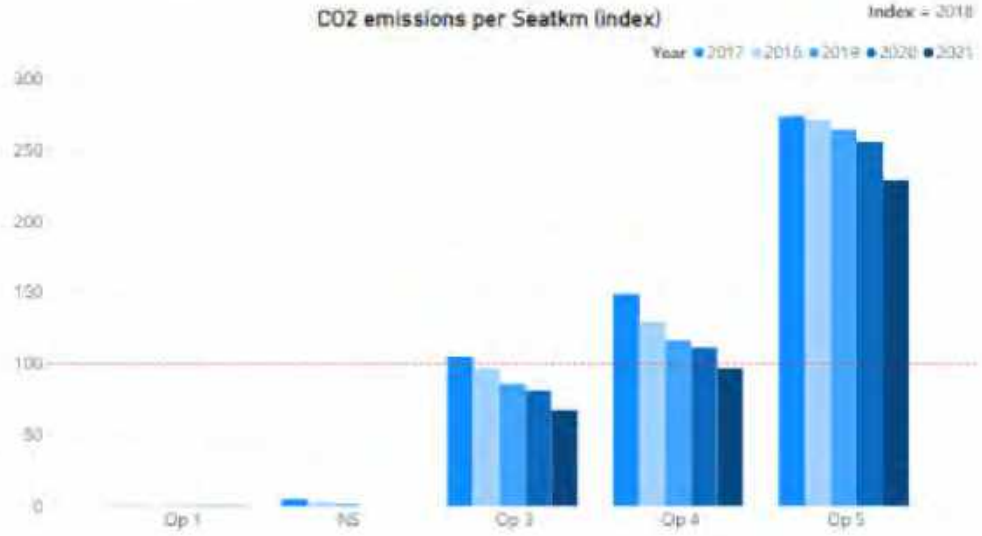
- Energy usage per seatkilometer stayed quite stable for most operators.
- The operators that realised an increase in energy efficiency did so mainly by replacing Diesel rolling stock by electric rolling stock.
- Factors contributing to NS' low energy consumption are:
  - Operating only trains with electrical traction
  - Modern rolling stock (with recuperative braking)
  - Energy efficient driving, facilitated by a driver advisory system (developed in-house)
  - Relatively low number of stops (compared to regional traffic of peers)

5.3 Sustainability – CO_2 emissions

CO_2 emissions per passengerkilometer increased due to the lower passenger numbers,
CO_2 emissions per seatkilometer declined due to increase of electric trains and energy from renewable sources



- During 2020 and 2021 the CO_2 emissions per passengerkilometer increased sharply in the case of a number of operators.
- NS and one operator only use traction energy from renewable sources, resulting in negligible CO_2 emissions.



- CO_2 emissions per passengerkm were steadily declining at all operators. This is mainly driven by a shift from Diesel trains to electric trains.
- The operators with the highest proportion of Diesel rolling stock are currently replacing this rolling stock by electric and/or bi-mode rolling stock.
- Additionally, there is a shift to sourcing from zero emission or low emission sources (hydro, wind, solar, nuclear).

5.4 Attractive Product for Passengers – *Trends, insights and practices*

Customer satisfaction is strongly driven by punctuality. Seating availability and capacity is enhanced by new planning methods ("standing minutes"), a reservation system and/or demand management measures.

Overall

- Most operators show rising customer satisfaction, both overall and on specific aspects.
- Customer satisfaction is strongly influenced by punctuality.

Seating availability and train capacity

- NS' improvement on seating capacity and utilisation is enabled by improving planning of rolling stock.
- One other operator realised a significant improvement in both customer satisfaction and utilisation by stepping up its reservation system.
- All operators discuss the possibilities of spreading the peaks in passenger demand. Some have implemented demand management measures involving pricing incentives.

Sustainability

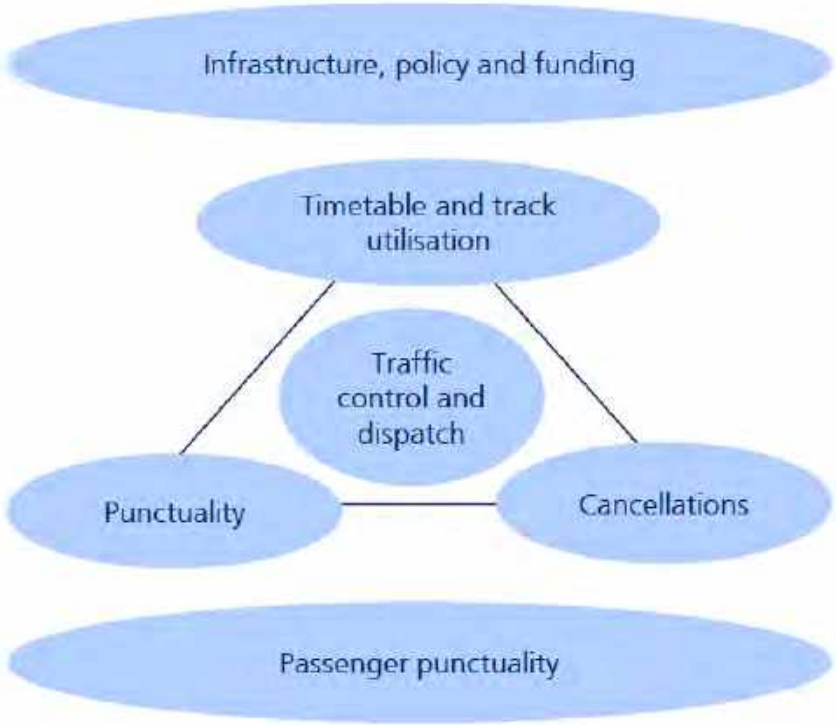
- Energy efficiency and emissions per passengerkilometer have worsened during the declining demand. However, the performance per seatkilometer has improved in most cases. Introducing new, electric or hybrid, rolling stock has proved to be an effective sustainability measure.
- Energy efficiency and CO_2 emissions per passengerkm can be expected to recover when passenger demand increases again.

Contents

6. Theme: Punctuality, Reliability and Frequency

Punctuality and reliability are strongly influenced by structural factors and operational trade-offs

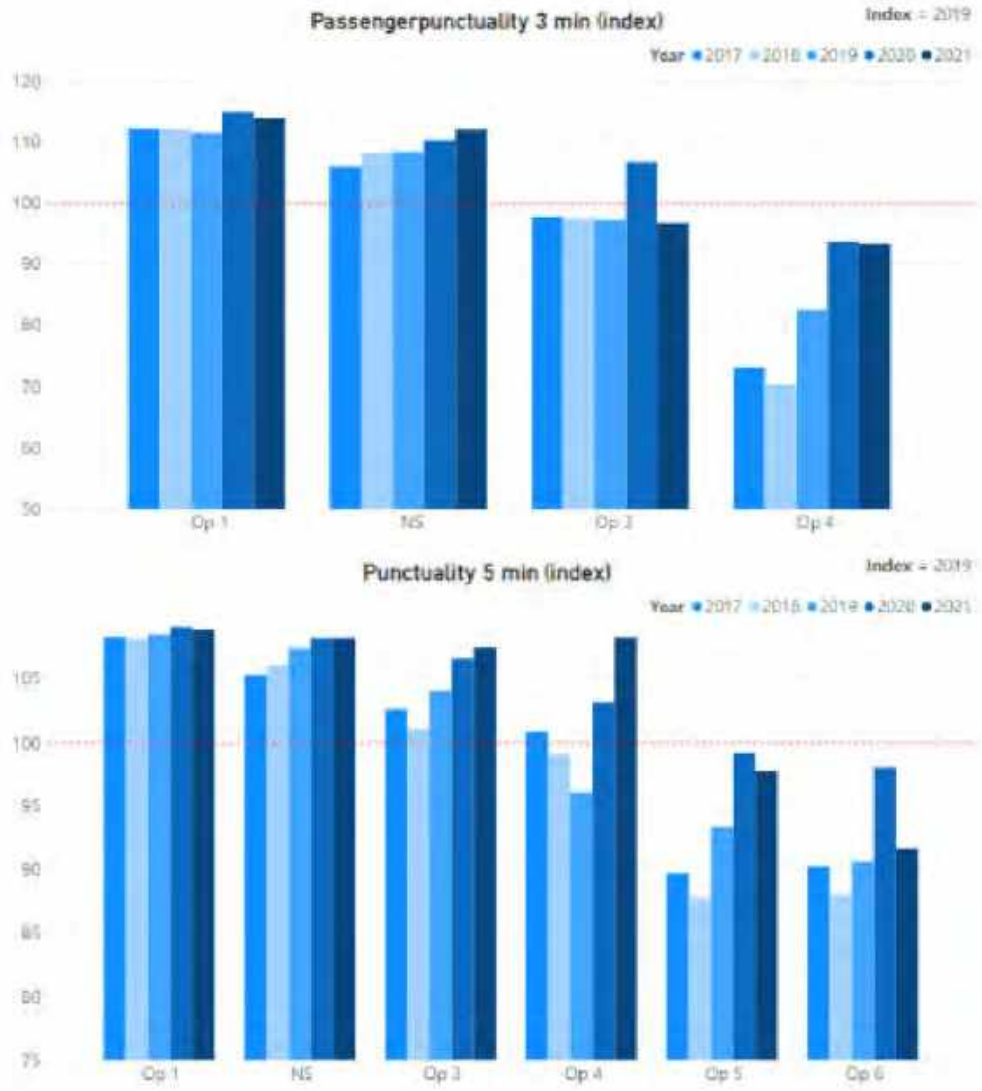
When comparing punctuality and reliability, differences in context, policy and strategy have significant impact on the output and outcomes. These differences encompass governments, operators and infrastructure managers.



- The most important structural variables are:
  - Structure of the timetable, frequency of trains
  - Condition of infrastructure and rolling stock
- The timetable (and thus the track utilisation) results from passenger demand, available infrastructure, rolling stock and staff.
- Disturbances in operation are handle differently in traffic control and dispatching, resulting in differences punctuality and reliability, that are both impacting passenger punctuality.
- NS and ProRail use a relatively high grade of automation. This enables fast disruption management, but it also increases operational vulnerability to IT failures.
- NS and two peers manage mainly performance based on passenger punctuality, focussing on the impact for passengers. The use of smartcard (check-in check-out) data enables NS to monitor and manage passenger punctuality with a high level of accuracy and precision.

6. Theme: Punctuality, Reliability and Frequency

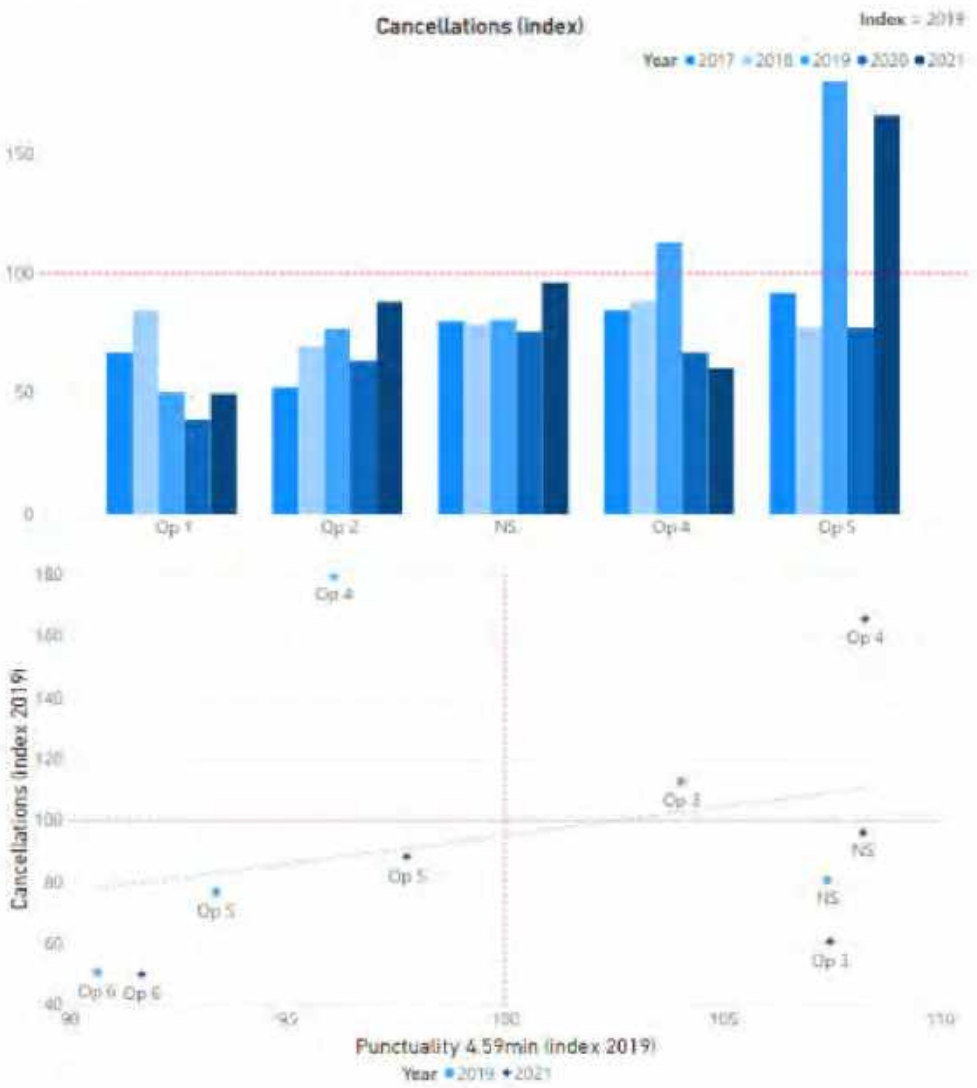
NS realized an above average and increasing passenger punctuality and train punctuality.



- NS has one of the highest levels of passenger punctuality and train punctualities of the peer group, while at the same time running one of the most densely operated networks.
- All train operators showed an increase of the punctuality during 2020. Some operators show a declining punctuality in 2021.
- Most operators cite the lower passenger demand as the main cause of the punctuality improvement. Lower passenger numbers enable shorter dwell times and thus more buffers on the station allowing for the better punctuality.
- Another factor that was also often cited was the increased slack due to the lower number of trains on the network. This factor appears to be less important, as some operators increased punctuality while hardly decreasing the number of trains.
- The best performing operators all had a joint operator / infrastructure manager control centre, to allow for fast coordination in case of delays and large disruptions.
- Some peers chose to add buffers in the timetable, making it more robust at the expense of more travel time for the passengers.

6. Theme: Punctuality, Reliability and Frequency

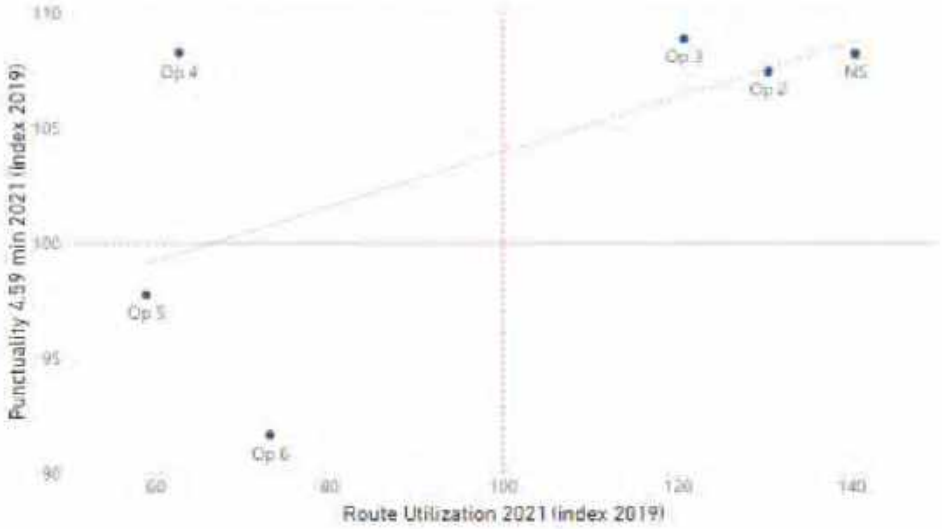
NS reports an average level of cancellations. Operators with lower cancellation levels sometimes skip stations to restore punctuality and avoid cancellations.



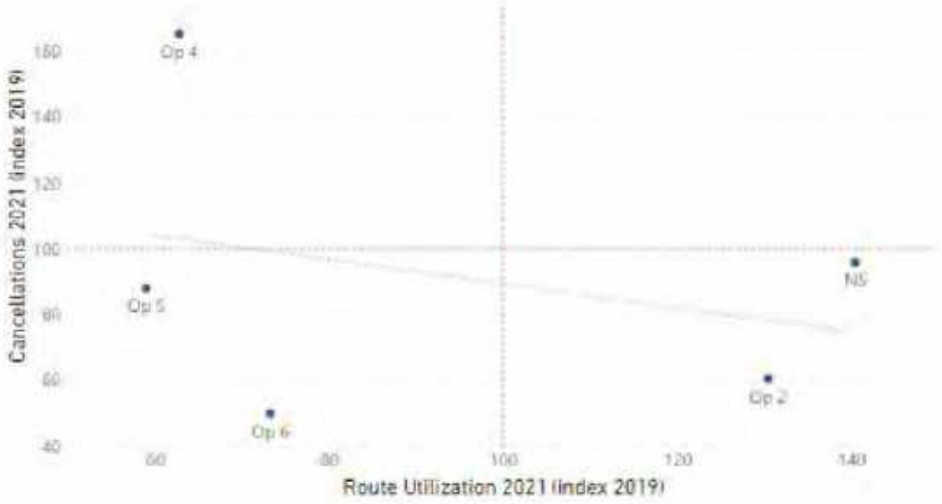
- NS has an average number of train cancellations compared to the other operators that provided this data. The peak in 2021 is due to weather circumstances (winter and storm), telecommunication failures and a shortage of traffic controllers.
- There are some difficulties comparing cancellation data due to the difference between full and partial cancellations. Therefore, interpretation of absolute values requires some caution.
- One of the operators does not report cancellations anymore, since cancellations are fully represented in the calculation of the passenger punctuality.
- Two operators have a policy to skip smaller stations before a bottleneck section if a train is delayed. This results in the train recovering its delay and prevents cancellation. These operators have rules how to serve the stations that were skipped (e.g. do not skip more than twice in a row). These rules result in an acceptable service level for passengers as reflected in the passenger punctuality KPI. NS only does this incidentally on high density lines, also focussing on passenger punctuality.
- In some cases, the replacing old rolling stock by new rolling stock improved the reliability, causing the decline of the number of cancellations.

6. Theme: Punctuality, Reliability and Frequency

High frequent train services may require high punctuality and involve different cancellation practices



- There are some indications that a high route utilisation (trainkilometer per trackkilometer) requires a high level of punctuality to ensure sufficient stability of operations.
- However, based on this relatively small dataset, there is no strong quantitative support for a relationship between punctuality and the intensity of train operations on the network.



- Based on this limited dataset, there is insufficient evidence to support a clear relationship between cancellations and route utilisation.
- In the discussions with the peers, it became apparent that operators with higher frequencies of train services were more inclined to skip stations or to cancel trains partially in case of disruptions.

6. Punctuality, Reliability and Frequency – *trends, insights and practices*

Punctuality

- All operators show higher punctuality numbers during 2020 and 2021 compared to earlier years, citing less passengers and less trains as main causes. Most operators see a decrease in punctuality when passenger numbers rise again.
- The (limited) data does not indicate that punctuality and/or reliability is/are negatively impacted by a high network utilisation. A high network utilisation rather requires a high punctuality and reliability.
- A joint operational control centre with the infrastructure manager and operator(s) on one location is generally seen as a good practice, that has contributed to a better punctuality and reliability.
- Some operators add buffers in the timetable, improving punctuality at the expense of longer travelling times and higher operational costs.

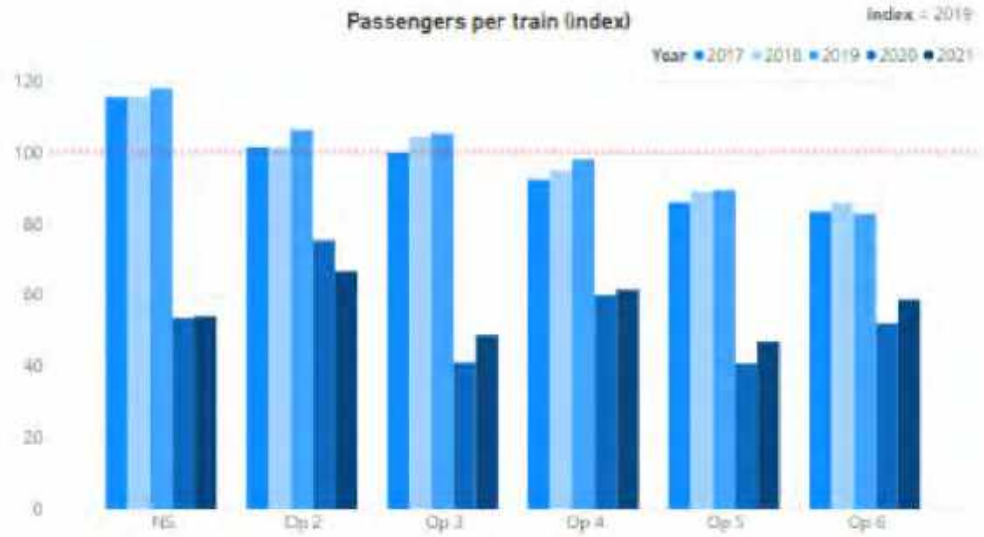
Reliability

- Three operators have a clear focus on passenger punctuality instead of train punctuality.
- One of these operators does not report partial train cancellations anymore, since it focusses on passenger punctuality and the "cancellations" KPI does not reflect the delay management choices well anymore.
- Two operators have practices to skip stations in case of delays before a bottleneck to optimize the overall passenger punctuality without cancelling trains. This involves a protocol that safeguards that the passengers on the skipped station do not have to wait too long to start/resume their journey.

Contents

7.1 Capacity and utilisation – *Trains and rolling Stock*

NS shows the highest decline of passengers per train and passengerkilometer per vehicle

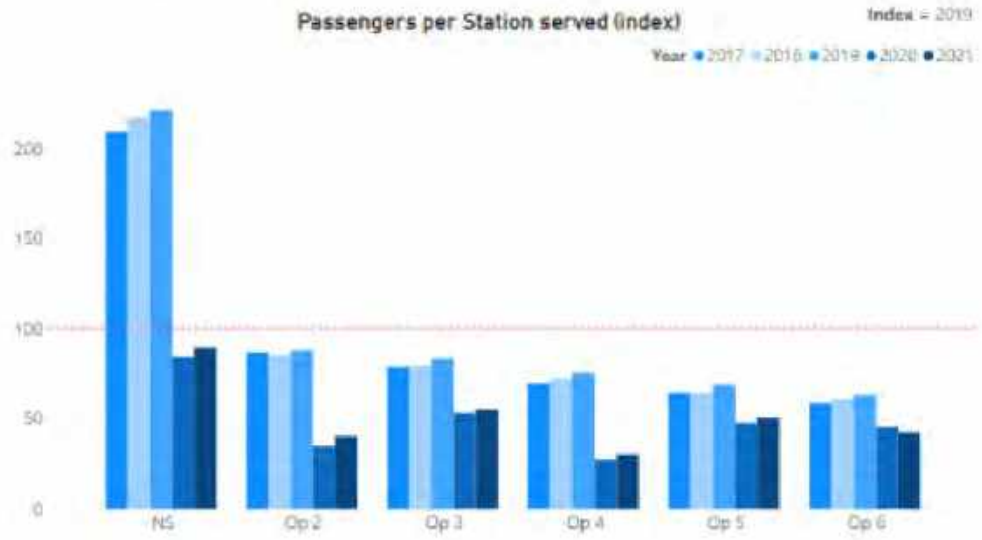


- Until 2019 NS had the highest number of passengers per train, resulting in a healthy cost/revenue balance. Due to the drop in demand and the maintained level of train services, the overall productivity on a train level has declined.
- Other operators show similar patterns, but due to the high-density operation of NS and the more severe decline in passenger numbers, NS performance on this KPI has suffered the most.

- The utilisation of rolling stock has dropped with the declining numbers of passengers. As NS face the highest level of decline, the decrease of the utilisation of rolling stock was the highest of the peer group.
- Both graphs indicate that NS was among the operators that were most severely impacted in the coverage of its fixed costs.

7.2 Capacity and utilisation – *Network and stations*

NS ranks among the operators with the highest network and station utilisation



- Over the entire benchmark period, NS is one of the operators with the highest network utilisation.
- Op3 also has a considerable amount of freight trains running on its network. As freight trains are out of scope for this benchmark, freight trainkilometers are not included in this comparison. If all trainkilometers on the network are included, Op3 has the highest network utilisation.

- The number of passengers per station decreased in 2020 and 2021.
- NS still ranks as the operator with the highest station utilisation of the peer group (74% above average). NS' station utilisation in 2021 is still above average station utilisation of the rest of the peer group in 2019.
- This high station utilisation is partly driven by the regionalisation of lines in the Netherlands, resulting in transfer of low-density lines and stations to other operators.

7.3 Capacity and utilisation – *Trends, insights and practices*

- Train utilisation is directly related to passenger demand and timetable design. With the declining passenger demand, all operators show lower train utilisation. In the case of NS this decrease was even above average due to the stronger fall in demand and relatively high train service provision.

- Rolling stock utilisation also decreased directly due to falling demand. This effect was slightly compensated because most operators faced delayed rolling stock deliveries due to supply chain disruptions.

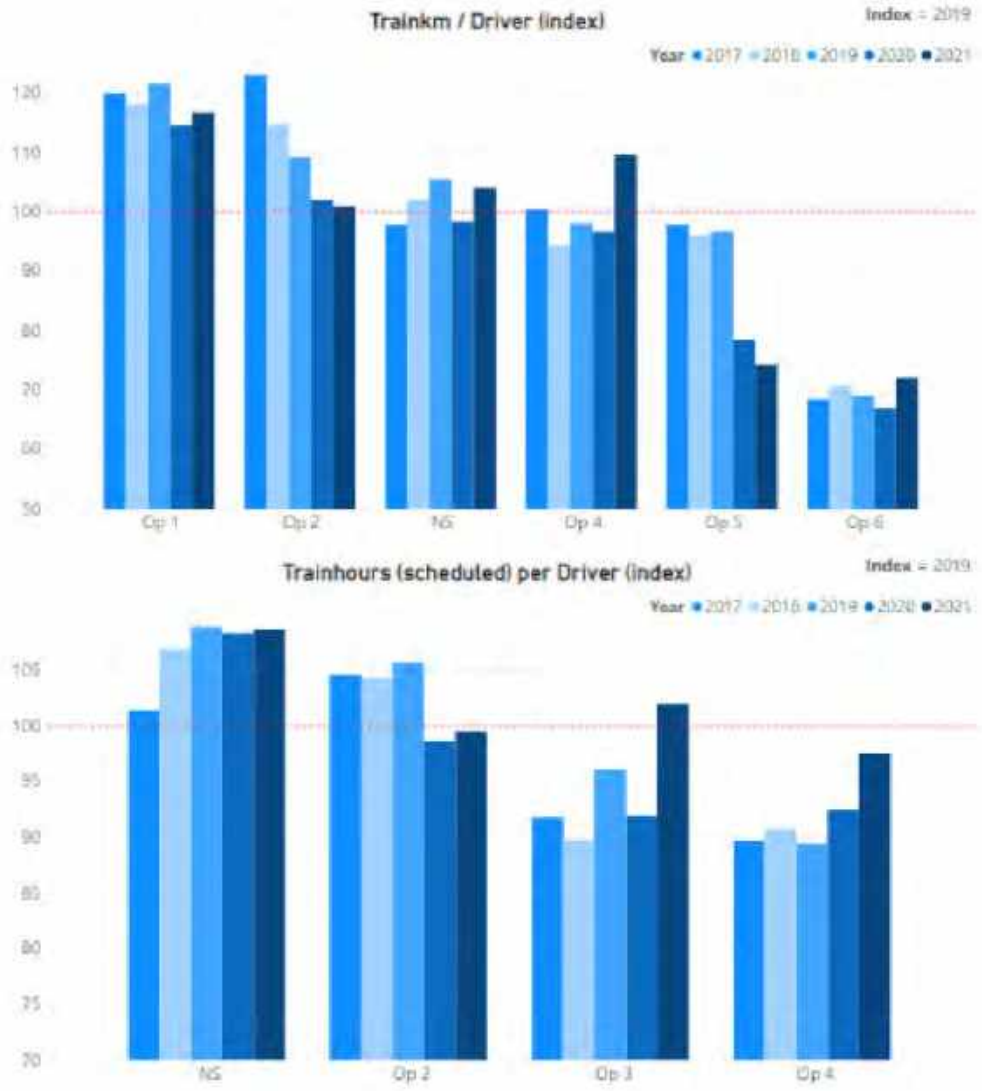
- Network utilisation is directly related to the train service offering. As this was reduced much less than the passenger demand, network utilisation did not face large changes.

- Station utilisation (passengers / station) decreased and increased in line with the passenger demand. Station utilisation also varies widely with the category of traffic. NS main network has a much higher station and network utilisation than regional lines.

Contents

8.1 Productivity – *Train drivers*

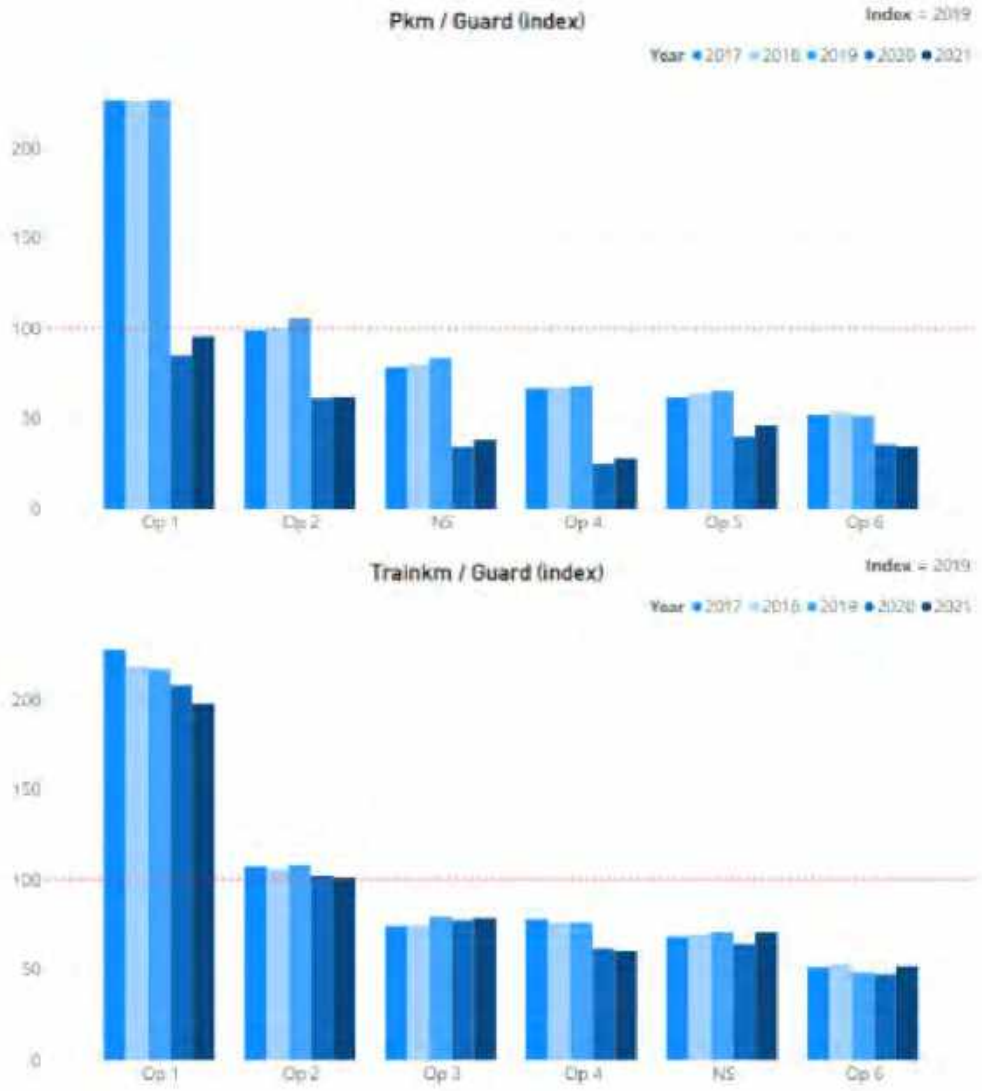
Train driver productivity showed wide variations caused by a range of factors, such as sick leave and a backlog in recruiting and training.



- During this benchmarking period the number of trainkilometers per NS train drivers was around the average of the peer group.
- The productivity in terms of trainhours per train driver was above average.
- Operators of the peer group were facing several factors impacting the productivity of their drivers:
  - Some operators reduced the train service offering, while the number of train drivers did not decrease at the same rate.
  - During 2020 and 2021 the sick leave increased, also due to testing and quarantine measures. This reduced the number of deployable train drivers, increasing the pressure on the others.
  - During 2020 and 2021 recruitment and training of new drivers was on hold or limited. This limited the number of train drivers that were available for service.
  - One operator increased the number of lines per depot that drivers were deployed to. This allows for higher efficiency in duty rostering. NS already uses this practice for a considerable number of years.

8.1 Productivity – *Train guards*

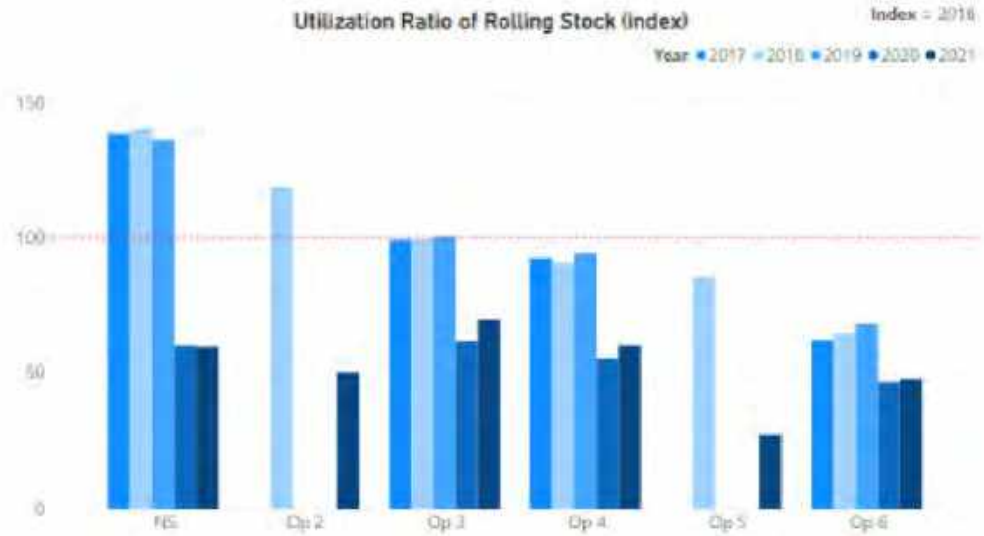
NS train guard productivity is strongly influenced by the operational model (guards per train)



- During 2020 and 2021 the passenger volume was reduced, resulting in a sudden decline in the number of passengerkilometers per train guard.
- NS has a below average number of trainkilometers per guard, as there is more than one guard per train on many trains.
- Operators with the highest productivity numbers run part of their trains without a guard but with mobile teams. Op1 and Op2 have no fixed guard on every train. The customer satisfaction on security train and on information in the train in case of disruptions is lower than average for this operator.
- Some operators deploy mobile teams instead of a guard for every train in one of the following cases:
  - Regional lines that are operated with relatively short trains
  - Suburban lines with dispatch staff on the platforms of the stations.
- Other factors include the same as those for train drivers; sick leave, hiring and training backlog, etc.

8.2 Productivity - *Assets*

utilisation of rolling stock decreased strongly, causing a drop in coverage of fixed costs. NS strongly reduced the number of vehiclekilometers to match reduced demand and decrease variable costs.



- The number of passengerkilometer per vehicle gives an indication of the cost coverage of the capital assets of the operator.
- Until 2019 NS had the highest utilisation of fleet of the peer group. During 2020 and 2021 the differences in passenger volumes moved NS towards an average ranking.
- All operators face a strongly reduced coverage of their fixed costs, but during this period NS was facing an above average drop in cost coverage.

- The number of vehiclekilometer per vehicle gives an indication of the efficiency of rolling stock deployment and rolling stock maintenance.
- Until 2019 NS far outperformed the other operators in the peer group. Since 2020 NS decreased the train capacity in line with demand, reducing variable costs.
- As the fleet is still needed when passenger demand recovers after the COVID-19 pandemic, the decrease of this ratio is only driven by changing passenger demand and not by inefficient operations.
- The graph below illustrates how NS realised the largest decrease in variable rolling stock costs.

8.3 Productivity – *Trends, insights and practices*

Staff

- All operators show a decrease of train driver and train guard productivity during 2020, partially restoring in 2021. The main factors are:
  - falling passenger demand and reduced service offering
  - increasing sick leave
- Staff shortage is also frequently mentioned as a serious issue, driven by:
  - sick leave and increased pressure on the other staff,
  - backlog in recruiting and training
  - aging workforce leading to increased numbers of retired staff that has to be replaced
- Several operators (among which NS) stepped up hiring and training efforts to alleviate staff shortages. This can include redesign of the staff profile and training programme.
- Operators with a higher productivity of guards usually operate with a lower average number of guards per train (e.g. some trains with mobile teams instead of fixed guards)
- Some operators are aiming to increase the productivity of staff by increasing the deployment area per staff depot. NS already has a wide deployment area per staff depot.

Rolling stock

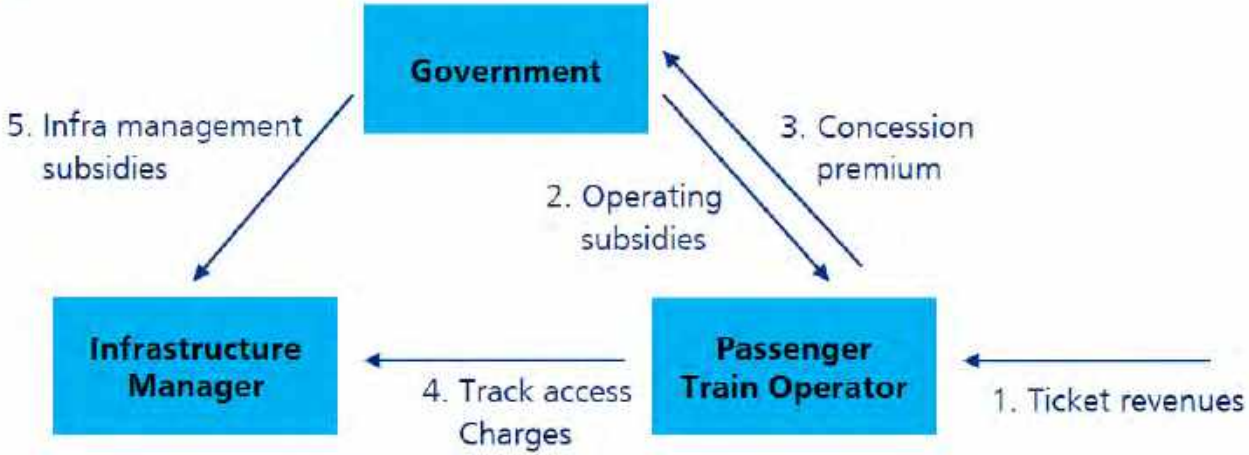
- All operators show a decrease of rolling stock utilisation, leading to a decrease of the coverage of fixed costs.
- Until 2019 NS had the highest rolling stock utilisation of the peer group, but due to the declining passenger demand the utilisation decreased to an average level.
- NS has reduced the train-length more than other operators, resulting in lower variable costs.

Contents

9.1 Financial - *Overview*

The structure and balance of financial flows in the railway sector varies widely over the peer group.

- A comparison of financial performance should include all relevant financial flows. The diagram illustrates the relevant flows (as numbered below).
- The total ticket revenues (1) divided by the total number of passengerkilometers indicates the cost level for passengers.
- The total operating subsidies (2) minus the concession premium (3) and minus the track access charges (4) indicates the total level of net public funding for the passenger train operator.
- The sum of ticket revenues (1) and net public funding (2 -/- 3 -/- 4) indicates the net revenues of the passenger train operator. When the operator does not make above average profits or does not increase debt, this figure also gives an indication of the cost level (assuming comparable financial results).
- The sum of operating subsidies (2) and infra management subsidies (5) minus concession premium (3) is a measure for the total public funding of the railway industry. Due to differences in operational situation (e.g. multiple passenger and freight operators) it is not possible to include this system-wide comparison in this report.
- The scope for this operations funding excludes funding of investments (e.g. infrastructure, stations and/or rolling stock). All financial comparisons are in current price levels, excluding VAT and corrected for purchasing power parities as described in Appendix B.4.



9.2 Financial – *Ticket revenues and public funding*

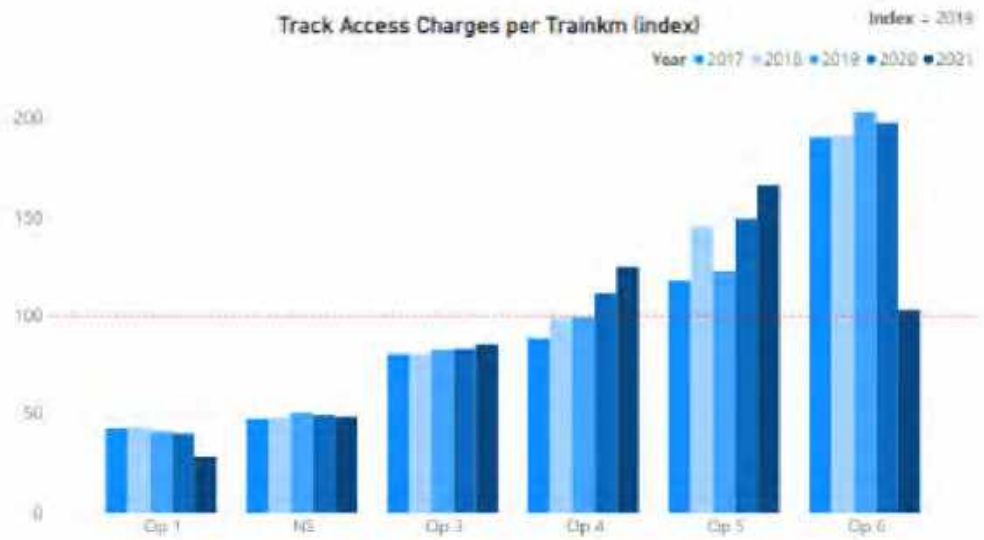
Ticket revenues per passengerkilometer increased due to season tickets and large contracts.
NS received one of the lowest levels of net public funding, both before, during and after the pandemic

- Several operators show an increasing level of ticket revenues per passengerkilometer during the COVID-19 pandemic. This is caused by revenues of annual tickets and large volume contracts that declined less than the actual passenger volumes.
- NS used to have an average level ticket revenues per passengerkilometer. The large increase during 2020 is mainly due to revenues from the Student Card; revenues continued while the passenger demand declined.
- Most operators moved to a different structure of season tickets, e.g. flexible rates or a "carnet style" proposition.

- Net public funding for the operator is defined as: subsidies – concession fee – track access charges
- Until 2019 NS and Op1 had significant levels of negative public funding.
- Since 2020 all operators receive net public funding. NS was among the operators receiving the lowest net public funding. In the case of Op3 this revenue loss was covered by a significant increase of the debt.
- Op6 additionally receives additionally a significant annual amount of investment funding that does not show in this graph.

9.3 Financial – *Track access charges*

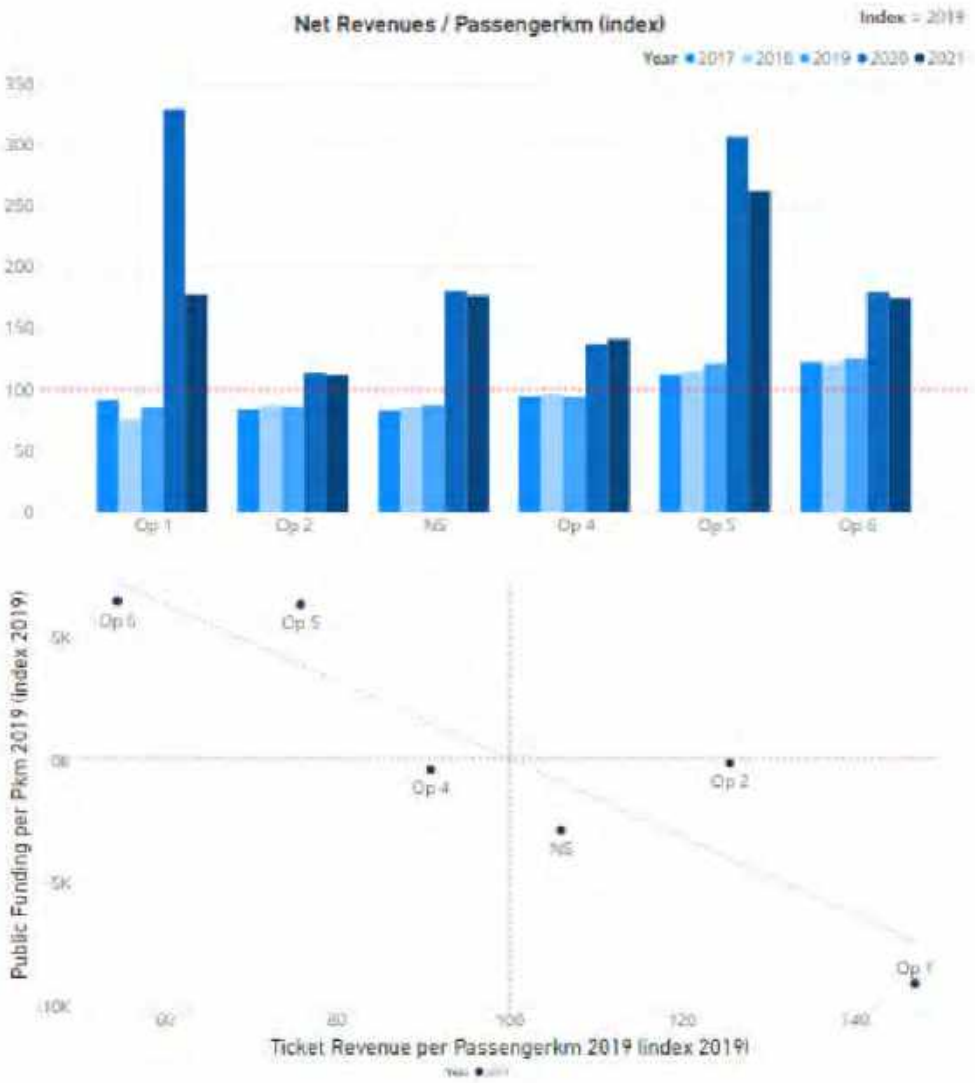
Dutch track access charges are below average following the financial structure of the Dutch railway sector



- For NS, the level of track access charges is around 50% of the average of the peer group.
- Op1 cited discounted track access charges during the last months of 2020 and during in 2021. This mainly shows in the 2021 figures.
- Op6 had its track access charges decreased in 2021 as a part of a rearrangement of the financial flows in the sector (between government, operator and infrastructure manager). Track access charges and subsidies to the operator were lowered, while the subsidy to the infrastructure manager was increased.

9.4 Financial – *Net public funding and net total revenues*

Ticket revenues and net public funding are negatively related; a political choice and not an efficiency measure



- Net revenues are defined as ticket revenues + net public funding. Normally this is a proxy of the unit cost level. However, some peers cited a increase of debt during 2020 and 2021, resulting in a distorted picture for these years.
- NS net revenues per passengerkilomer is below average. Until 2019 NS was among the most financially efficient operators. During 2020 and 2021 there were several operators with lower revenues per passengerkilometer. As the fixed costs remained constant this resulted in increased debts, distorting the picture.
- This graph excludes investment subsidies of one operator. Including these would rearrange the ranking, with NS as one of the two operators with the lowest net revenues per passengerkilometer.
- Ticket revenues and net public funding show a negative relation; lower ticket revenues requires higher public funding.[1]
- The balance between ticket revenues and public funding is a political choice and does not directly reflect the efficiency of the operator or the railway system.

1. As public funding, profit margins and changes in debt varied widely in 2020 and 2021, the lower graph uses 2019 for comparison

9.4 Financial – *Trends, insights and practices*

NS had an above average decrease of ticket revenues.
Peers show a variety of government support arrangements.

- During 2020 and 2021 the financial arrangements between governments, operators and infrastructure managers were very different from earlier years. Some elements could be included in the financial comparison, such as specific COVID support for operators. Other elements are out of scope, or hard to determine, such as infrastructure financing and changes in the debt position of the operators of the peer group. This makes that one should be cautious when interpreting the comparisons.
- All operators were compensated for revenue loss in 2020 and 2021, but different mechanisms and cost coverages were in place:
  - Transfer of the revenues from the operator to the government and covering allowable operational costs of the operator (emergency contracts and gross contracts).
  - Covering all costs that were not covered by ticket revenues (net contracts).
  - Covering a part of the costs that were not covered by ticket revenues (COVID-19 support).
  - Compensation ticket revenu loss for regional transport contracts only, not for intercity operations.
- For NS, the ticket revenues increased in 2020 and 2021, because the passenger demand declined, while the funding for the Student Card remained in place.
- Before, during and after the pandemic, NS net total revenues and net public funding per passengerkilometer were among the lowest of the peer group. The balance between public funding and passenger fare levels reflects political choices regarding the funding of public transport. The low net total revenues per passengerkilometer indicates a relatively efficient operation by NS.

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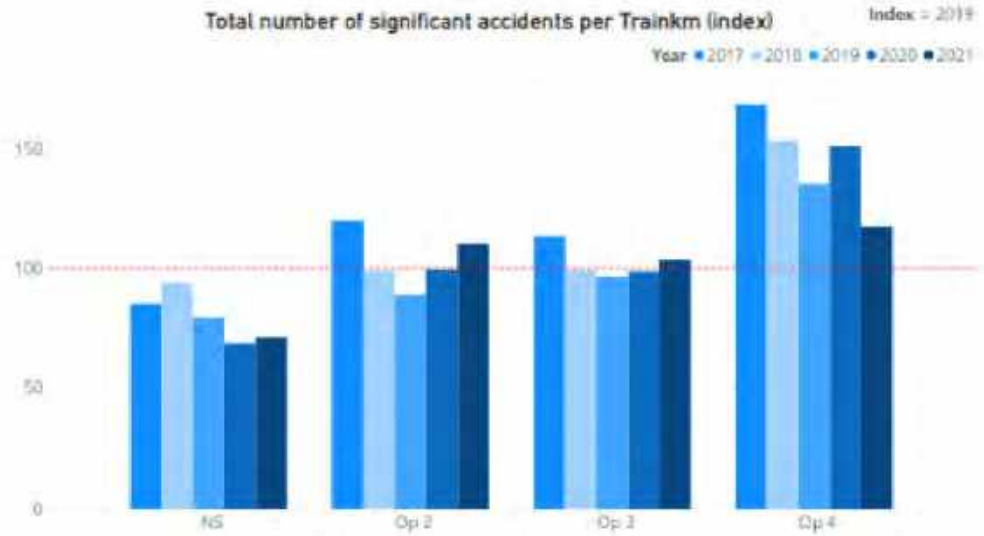
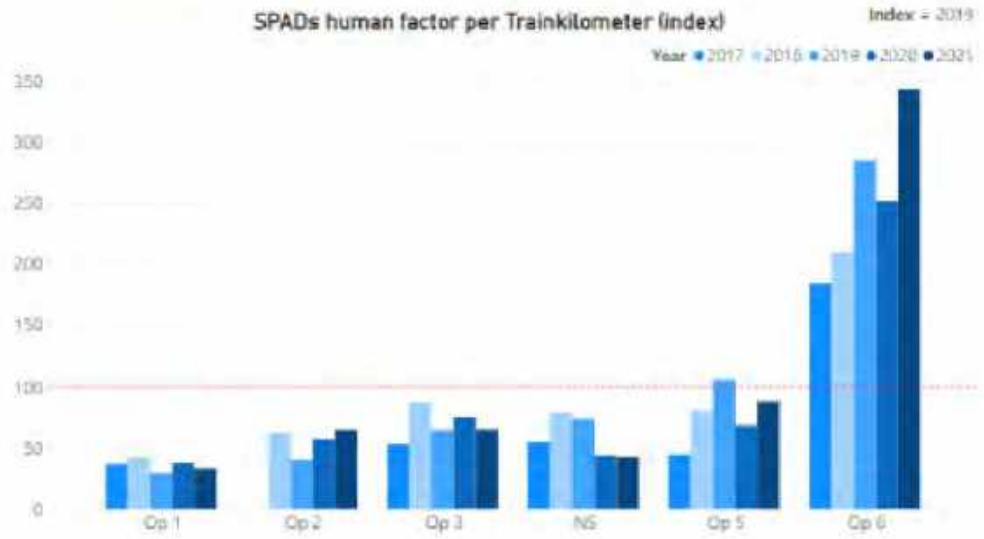
10.1 Operations and Infrastructure Management - *Safety*

NS has the lowest level of significant accidents and a below average level of Signals Passed At Danger



- NS consistently has the lowest number of significant accidents per trainkilometer of the peer group.
- A separate international case study on Safety Culture shows that NS has a relatively well-developed safety culture, including organizational support and systems.
- Only few accidents have led to fatalities or serious injuries for passengers or empoyees, no stable trend could be found.



- NS has a below average number of Signals Passing At Danger per trainkilometer.
- In a separate international case study on SPADs NS also shows a modest level of SPADs. NS realised this despite a relatively high signal density compared to that peer group.
- Operators with relatively high levels of SPADs are expected to benefit the most from the introduction of ERTMS.

10.2 Operations and Infrastructure Management – *Extreme weather*

In discussions with the peer group of some topics were mentioned:

- Most operators and infrastructure managers have joint season preparedness plans, including procedures and criteria for measures in operation. Measures are based on weather forecasts and conditions and carried out in close coordination.
- In the past operators and inframanagers mainly focussed on measures to deal with autumn problems (leaf-fall and storms) and winter problems.
- Autumn measures include increased alertless on weather conditions, wheel rail conditioning to increase adhesion, extra inspections and maintenance and repair activities.
- Winter measures include extra attention for point heating, de-icing and timetable adaptations based on priorities.
- Increasingly also summer heat problems are mentioned, that lead to infrastructure failures (e.g. trackside fires) and rolling stock failures. Measures include extra inspections and maintenance and repair.
- In recent years railways are also increasingly faced with floodings, drought and track stability issues. Global warming gains increasing attention. Building resilience will require targeted investments.

As climate issues increasingly impact the performance and costs of railway operations and infrastructure, this may be a topic for further research.

West Midlands Trains, 2019

SpoorPro, 2021

10.3 Operations and Infrastructure Management – *Engineering works*

- Tracks require maintenance and renewal, especially when intensively used. Most operators are faced with increasing track works by the infrastructure manager. This increased level of track works has a negative effect on punctuality.
- During this benchmark, no data was available to perform a meaningful quantitative comparison of track works and the impact of track possessions.

Network Rail

An international case study on track works provided some qualitative views:

- Compensation for extra operational costs and revenue loss due to engineering works varies widely. In one case the infrastructure manager covers the entire revenue loss of the operator. This promotes a more integral trade-off between the costs of the works and the impact of the track works on passenger train operations.
- Infrastructure works can have a major impact on punctuality. It is a good practice to evaluate the impact on transportation and performance (punctuality, cancellations, etc) in an early stage of decision-making using feedback from earlier engineering works.[1]

- During the pandemic many infrastructure managers accelerated track renewals, as the impact on passenger operations was limited. In other cases, there were delayed track works due to disruptions in supply chains and higher sick leave. This caused some deterioration of infrastructure quality.

1. Process map: NMBS, used with permission

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Appendix A: Follow-up audit 2020

The International Benchmark of 2020 was reviewed by KiM Netherlands Institute for Transport Policy Analysis. KiM made the following general recommendations:

1. Be careful to draw conclusions, given the complex contexts, outliers, the required indexation of insights, etc.
2. Focus on topics that are relevant to policy making.

This benchmark study followed up on these recommendations

1. Comparisons include information about relevant context and practices that were collected in the discussions with the peers. Where relevant, comparisons indicate the limitations of comparisons, e.g. limited data.
2. This report focuses on key performance areas, such as customer satisfaction, productivity and financial performance. It also provides in-depth considerations about themes that were selected with the Ministry of Infrastructure and Waterworks: impact of COVID-19, punctuality, reliability and frequency, and interaction between the operator and the infrastructure manager.

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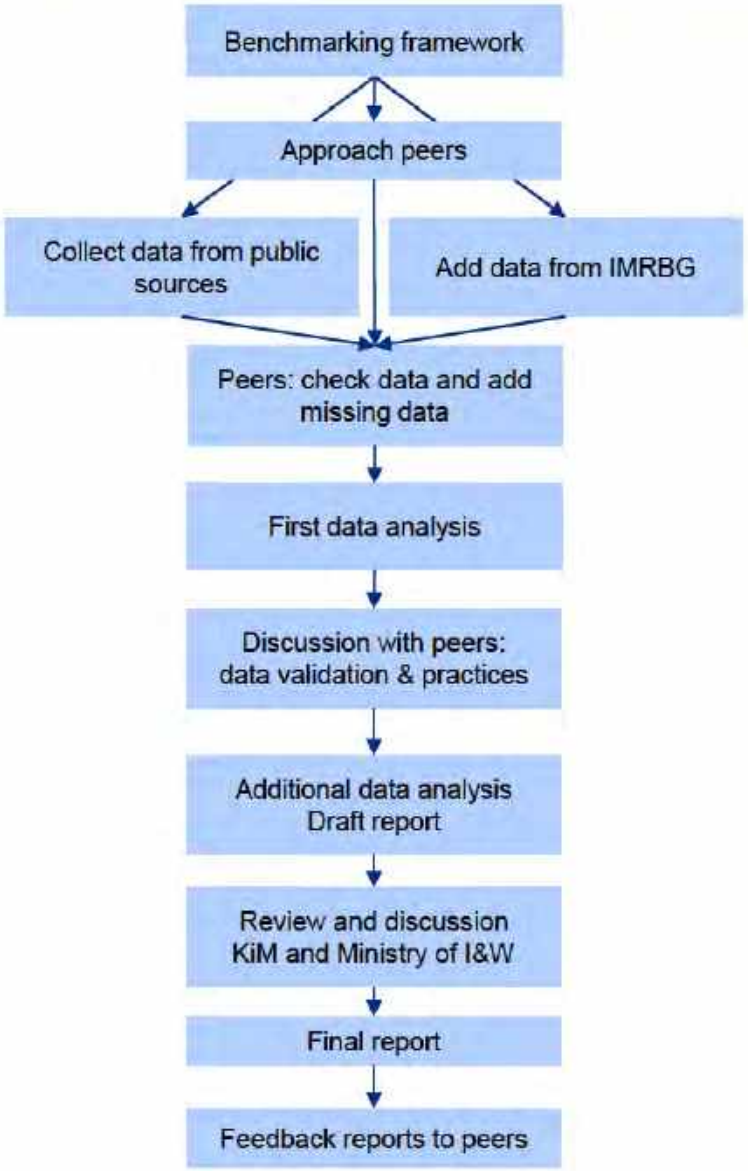
Appendix B.1 Methodology – *Data collection, analysis and reporting*



- Data was collected as much as possible from public sources, such as annual reports, statistical agencies, government websites, etc.
- DSB, NMBS and NS are members of the International Mainline Rail Benchmark Group [1] (IMRBG). Data from IMRBG was added, as verified data.
- Missing data was added by the peers.
- After a first data analysis, the data and practices were discussed with the peers to verify data and identify best practices and contextual factors impacting performance.
- The draft report was reviewed by KiM (Netherlands Institute for Transport Policy Analysis) and the Ministry of Infrastructure and Waterworks.
- After finalizing the report the peers receive customized feedback reports.

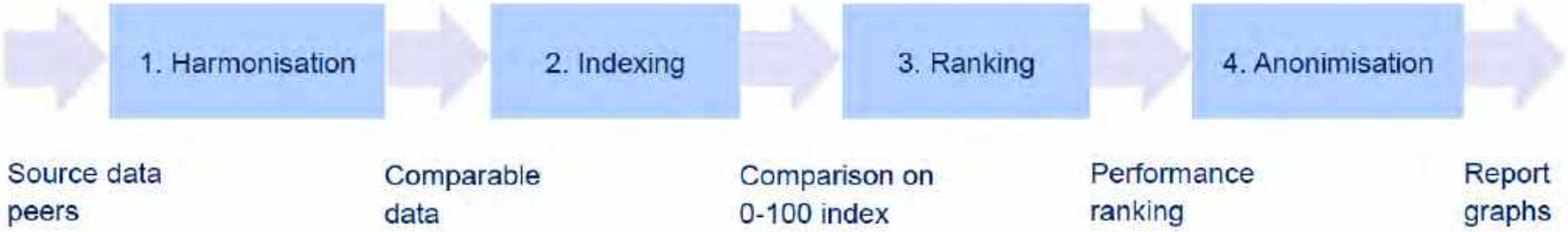
1. International Mainline Rail Benchmark Group: https://mainlinerail.org/

Appendix B.1 Methodology – *Harmonisation and anonymisation*

1. Harmonization
   In the following sheets the harmonization processes for a number of parameters (customer satisfaction, reliability, financial) are summarized.

2. Indexing
   The indexing step divides all data from the preceding step by the average of the scores in 2019 and multiplies by 100. Therefore, all data is expressed as percentages of the 2019 average. Where 2019 data was not sufficient for a representative index, 2018 was chosen as index year (and indicated in the graph).
3. Ranking
   After indexing the data is ranked by performance, in a descending order of performance.

4. Anonymization
   All peers are labelled by their performance ranking Op1 to Op6 (operator), except NS and/or the peer for which a feedback report is intended.
   Publicly available data however is not anonymized. If data is public, steps 2 and 4 are skipped in the process.



The indexing, ranking and anonymization protocol is in accordance with the confidentiality agreement of the International Mainline Rail Benchmarking Group, as drafted by Imperial College in London

Appendix B.2 Methodology – *Harmonisation of Customer Satisfaction*

Comparable output

- Customer satisfaction scores are to be compared as close as possible to the NS score of "percentage respondents scoring a 7 out of 10 or higher". Most peers delivered data in this format.
- For SBB customer satisfaction figures were based on mean values (100-point scale).
- UK customer satisfaction is measured as "percentage satisfied or very satisfied", which is comparable to "percentage 7/10 or higher".
- As this harmonization adds some "noise" it is advisable to focus on comparing trends instead of absolute values.

Methodology of customer satisfaction survey

- Different peers use different survey methodologies:
  - Continuous vs. spring / fall surveys
  - Questionnaire online vs. paper forms that are distributed within trains
  - Inviting passengers on train for an online questionnaire vs. using a panel (including non-users)
- This benchmark does not correct for these differences

Appendix B3.2 Methodology – *Harmonisation of Punctuality*

Passenger punctuality

- Passenger punctuality expresses the percentage of passengers that arrive on their destination on time.

- DSB, NMBS, NS and SBB use this measure, but in different forms.
  - NS calculates passenger punctuality based on check-in and check-out times of public transport smart cards.
  - The other operators base their calculations on the arrival punctuality of trains, weighted by the number of passengers in these trains.
- Differences of calculation methods (e.g. using smart card passenger counts) are not taken into account for this comparison.

- Threshold times; different operators use different times when counting delays:
  - DSB and SBB calculate passenger punctuality based on a 3-minute cutoff time (2.59). NS data is recalculated using this cutoff time for comparison.
  - NMBS measures punctuality based on a 5 minutes 59 seconds cutoff time. NMBS data is converted with the linear regression model used for train arrival punctuality.

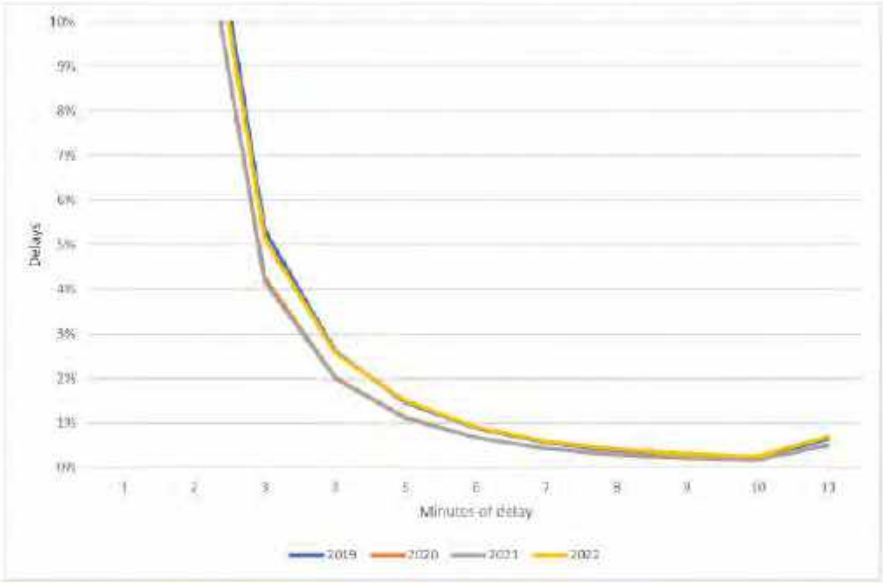
Cancellations

- Cancellations are compared based on the NS calculation of cancelled trains; number of trains passing measurement nodes divided by the planned number of trains to pass these nodes (based on the daily timetable, fixed 48 hours in advance)

Appendix B3.2 Methodology – *Harmonisation of Punctuality*

Punctuality of train arrivals

- Train arrival punctuality is compared based on the NS / ProRail measuring method and definitions; the percentage of trains arriving within 4 minutes 59 seconds from the planned time on the main (35) nodes on the network, excluding cancelled trains.
- For UK the 5-minute punctuality of arrivals on intermediate stations is used, and not the passenger performance measure that only measures on terminal stations.
- For the other operators, the effect of measuring on nodes or end points has not been taken into account for this comparison.
- Data from peers using different cutoff times for delays is harmonized using three linear regression models of arrivals of NS trains during 2019 -2022 using different cutoff times (n = 1461, R^2= above 0,95).



Appendix B.4 Methodology - *Financial*

- Financial data was harmonized using:
  - exchange rates from the European Central bank
  - Purchasing power ratios from OECD
- Resulting correction factors are summarized in the table below

Country	Currency	2016	2017	2018	2019	2020	2021
Belgium	EUR	1,018	1,008	1,013	1,036	1,038	1,038
Denmark	DKK	0,112	0,114	0,115	0,117	0,117	0,117
Netherlands	EUR	1,000	1,000	1,000	1,000	1,000	1,000
Switzerland	CHF	0,662	0,659	0,659	0,675	0,679	0,683
United Kingdom	UKP	1,155	1,142	1,129	1,155	1,123	1,135

PPP to NL EUR (nominal)

Contents

Appendix C. Structural characteristics of the peer group

- DSB operates a network with a strong East-West axis. In the West the traffic is concentrated to and from Copenhagen. It operates less rural lines than average, since these are tendered out by the Danish government. The network length is around 67% of the network operated by NS.
- Greater Anglia operates a network around London, with mainly commuter rail, but also some intercity lines. Traffic is strong London centric. The network length is around 75% of the network operated by NS.
- NMBS operates a network with a strong East-West axis and a strong North-South axis. Peak hour traffic is concentrated to and from Brussels. The number of stations is relatively high. The network length is around 67% higher than that of the network operated by NS.

Appendix C2. Structural characteristics of the peer group

- NS operates an integrated national intercity and commuter network. Traffic is multi-centric in the Randstad area. Most regional lines are tendered out by regional authorities and operated by other operators.
- SBB operates integrated national intercity, commuter and regional networks. Traffic is multi-centric between the large cities. The total network length is around 50% higher than the Main Rail Network operated by NS.
- West Midlands Trains operates under two brands. London North Western is an intercity / commuter network between London and Birmingham. West Midlands Rail operates mainly commuter and local lines around Birmingham. The network length is around 40% of that of the Main Rail Network operated by NS.