The quality of the international intercity train services within the Benelux

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Notification: *This paper is a slightly revised version of the paper that is published in the proceedings. After publishing we found a serious deficiency in the data used for the estimation of OD flows. The figures in this paper are based on corrected data.*

Abstract: *International train services generally have lower qualities and are less stable in time then domestic train services. The paper shows that this is also valid for cross-border services within the Benelux compared to domestic services in the Netherlands. The cross-border services have significantly lower qualities with respect to speed, detours, frequency, and transfers. A good integration of timetables for the networks of neighbouring countries and addition of direct international train services on longer distances might enhance the quality for cross-border travelling. The development of standards for required quality might encourage operators to improve their services, while authorities could use them for defining regulations in concessions.*

Keywords: intercity train, service quality, international, Benelux

1. Introduction

Cross-border public transport services generally have lower qualities and higher fares than domestic services. Moreover, the offered level of service is for cross-border services less stable over time than for national services: both strong improvements and deteriorations can be observed. Examples of changing service levels are developments in the train services between the Netherlands and Germany where local train connections are strengthened and most direct intercity services have been removed, and the frequent addition and removal of overnight train services. Most striking example is the intercity train service between Amsterdam and Brussels. After opening of the high speed line in this corridor and dropping out of the high speed trains, the quality in terms of travel speed and frequency showed a yo-yo effect.

In the Netherlands, a clear dissatisfaction with the relative low quality of international train services has been showed by Nobel et al (2014). Govers and Beuckens (2014) stress the importance of good train connections between larger cities, including the international connections. Definition of standards for the service quality, that are almost lacking for international services, might raise the service level. Operators could use such standards for designing their services, and authorities could use them for defining regulations in concessions. Standards should be tight in the sense that they warrant a reasonable quality but they should also be feasible with respect to technical conditions, and internal and external costs. For reasons of feasibility, standards for international services might be somewhat lower than for domestic services, because generally flows on international connections are smaller for comparable OD-relations.

One way to get an impression of what is at least feasible is just investigating the actually supplied qualities. These provide a 'revealed' feasibility and can be a starting point for defining standards. The aim of the paper is to map the current qualities of train services, being

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a first step in defining standards. The investigated train services are the intercity services within the Benelux, and in particular the international services. The quality indicators are limited to network and timetable qualities and exclude facilities in the trains or at the stations. The indicators also exclude unreliability of travel times and the extent connecting trains are missed, because of lacking data. The indicators assessed in the paper are travel speeds, detour factors, number of transfers, transfer time when making an interchange, and service frequency. These indicators are developed for the connections between the main intercity stations and will generally be more favourable than the qualities that the travellers are faced with, who have to make in addition access and egress trips to and from the stations.
The quality of the services is investigated for both the current services (2015), the planned adapted intercity train service between Amsterdam and Brussels starting in December 2016, and some improvements of the international services that were partly proposed by us in another paper (Van Goeverden, 2014).
The analysis in the paper exists of two steps: selection of the stations that are used for determination of the service qualities, and the determination of the qualities for the connections between the selected stations. These two steps are subsequently discussed in Sections 2 and 3. Section 4 includes some concluding remarks.

2. Selection of stations

The selection of major railway stations is based on criteria regarding size of the city, connection of public transport nodes in higher level networks, and spatial accessibility.
The selection on city size is based on number of inhabitants of the municipality. In the Netherlands, municipalities that have more than 100,000 inhabitants are selected. In Belgium and Luxemburg, the lower limit is 70,000; this number is lower than the Dutch one because the municipalities in Belgium and Luxemburg cover generally smaller areas. In addition some cities are selected which number of inhabitants is somewhat below the limit but that are the centre of a much more populated area (like the Dutch city of Heerlen). If several municipalities of sufficient size belong two one agglomeration, just one station for the agglomeration is selected.
Nodes of higher level networks include train stations served by long distance express trains and major airports. Long distance trains stop only at the main stations of larger cities and are automatically selected when larger cities are selected. Major airports are located outside the cities. The selection includes the train stations of two airports: Amsterdam airport (Schiphol) and Brussels airport (Zaventem).
With regard to the spatial accessibility of the selected stations, we adopt the criterion suggested by Immers et al (1994) that the distance to the nearest station should principally be no more than 40 km crow-fly. In order to serve so far uncovered areas, a larger city in the area is selected, or one of the largest settlements located centrally in the area if there is no large city. The latter applies particularly for the southern Ardennes. This is a large area where the largest settlements have 10,000-20,000 inhabitants. Here we selected Libramont, one of the larger settlements in the area, located along the main line Brussels-Luxemburg, and a node in the railway network.
Table 1 lists the selected stations, the reason for selection, and two indicators for importance that are used in the next section where the service quality is assessed. One indicator is the number of long distance journeys that starts or ends in the area served by a station, the second is a qualification based on number of inhabitants and level of provided services.

Station	Reason for selection	Annual LD-journeys (millions) made by		Classification
		Inhabitants	Visitors	
Middelburg	Access	1.4	4.0	3
Dordrecht	City size	0.8	0.2	3
Rotterdam Centraal	City size	5.5	4.4	1
Den Haag Centraal	City size	6.4	3.5	1
Leiden Centraal	City size	2.1	1.9	3
Haarlem	City size	1.4	1.4	3
Alkmaar	Access	3.3	2.7	3
Schiphol	Node higher level network	4.5	0.4	3
Amsterdam Centraal	City size	7.4	7.4	1
Almere Centrum	City size	1.1	1.1	3
Utrecht Centraal	City size	3.9	3.6	2
Hilversum	Agglo size	1.3	0.3	3
Amersfoort	City size	2.6	0.6	3
Zwolle	City size	2.0	4.2	3
Leeuwarden	Access	4.8	7.4	3
Groningen	City size	4.7	4.1	3
Emmen	City size	2.4	1.9	3
Breda	City size	5.3	1.7	3
Tilburg	City size	1.6	1.8	3
‘s-Hertogenbosch	City size	2.2	1.1	3
Nijmegen	City size	2.1	2.0	3
Arnhem	City size	4.0	2.7	3
Ede-Wageningen	City size	0.6	0.9	3
Apeldoorn	City size	1.7	2.8	3
Enschede	City size	5.6	3.8	3
Eindhoven	City size	3.8	1.9	2
Venlo	Access	2.4	1.6	3
Maastricht	City size	2.6	5.2	3
Heerlen	Agglo size	2.1	2.2	3
Antwerpen-Centraal	City size	6.7	4.5	1
Sint-Niklaas	City size	1.2	0.1	3
Gent-Sint-Pieters	City size	2.2	2.5	2
Brugge	City size	1.2	7.4	3
Oostende	City size	2.5	10.9	3
Kortrijk	City size	4.4	1.0	3
Aalst	City size	0.5	0.2	3
Mechelen	City size	0.7	0.2	3
Brussel-Luchthaven	Node higher level network	3.3	0.2	3
Brussel-Centraal	City size	17.4	9.7	1
Tournai	City size	1.2	0.6	3
Mons	City size	1.4	0.3	3
La Louvière-Sud	City size	0.9	0.6	3
Charleroi-Sud	City size	7.8	0.8	2
Namur	City size	1.7	1.9	3
Libramont	Access	6.1	8.2	3
Leuven	City size	3.0	1.4	3
Hasselt	City size	4.9	3.7	3
Liège-Guillemins	City size	6.9	1.1	2
Verviers-Central	Access	4.2	5.7	3
Luxembourg	City size	0.8	3.9	2

Table 1 : Selected train stations

The number of long distance journeys is determined using data of the DATELINE-project, a European survey on long distance travelling, and includes the journeys >= 100 km crow-fly (all modes). In the case of the two airports the number is set as the number of journeys by airplane starting or ending in the Netherlands (Amsterdam airport) or Belgium (Brussels airport) with the exception of journeys to or from the airport region itself (the conurbations of Amsterdam-Utrecht for Amsterdam airport and Brussels for Brussels airport).
The qualification of the cities include three classes: cities over ca 500,000 inhabitants (indicated by "1" in the table), cities of ca 200,000-500,000 inhabitants (indicated by "2"), and smaller cities (indicated by "3"). The city of Luxemburg that has just over 100,000 inhabitants got the higher classification of 2 because of its high importance in providing services, partly on European level.

3. Quality assessment

A number of quality indicators are valued describing averages for the international train services connecting the selected cities. The indicators include:

- Speed (km/h). This is the distance between station A and station B divided by the scheduled time needed for travelling between the two stations. This time includes transfer time, which means that the speed reflects the speed that the travellers experience; this is lower than the speed of the train in the case a transfer has to be made. Two speed indicators are valued: one using the crow-fly distance, and one using the actually travelled distance.
- Detour. This is the ratio between the actual distance and the crow-fly distance.
- Frequency of services (# per hour).
- Number of transfers per OD-trip.
- Transfer time per OD-trip (minutes).
- Distance (actual) between two transfers.
- Share of transfer time in total travel time.

Both unweighted and weighted indicators are assessed. The unweighted indicators describe the averages for all OD-connections, the weighted indicators are calculated by weighting the values for individual OD-connections by an estimation of the flows. The latter are estimated as the sum of (1) the production of zone O (journey numbers made by inhabitants of O) multiplied by the attraction of zone D (journey numbers made by visitors of D) and divided by the square crow-fly distance between O and D, and (2) the production of Zone D multiplied by the attraction of zone O and divided by the distance. The journey numbers used for valuing productions and attractions are listed in Table 1.
Table 2 shows the indicators for the current services according to the timetables. The table lists both figures that exclude and figures that include high-speed train services (Thalys). The reason for presenting figures excluding these services is, that their conditions for admittance (yield management and seat reservation obligation) are not convenient for relatively short distances like those within the Benelux. Decisions to make trips on smaller distances usually are made rather shortly before and then people trying to travel by high-speed trains might be faced with fully booked trains or excessively high fares. The findings of Klein (1998) are illustrative. Replacement of express train services from Paris to the west of France at normal speed and with normal conditions by high-speed services with yield management and seat reservation obligation (TGV Atlantique) induced a significant decrease in patronage on distances shorter than 400 km.

Indicator	Excluding HST services		Including HST services	
	unweighted	weighted	unweighted	weighted
Speed (crow-fly distance)	47	44	54	50
Speed (actual distance)	66	64	77	72
Detour	1.42	1.57	1.47	1.59
Service frequency	0.96	0.96	0.80	0.86
# of transfers per trip	2.24	1.64	1.98	1.48
Transfer time per trip	32	22	31	22
Distance between transfers	113	104	134	118
Share of transfer time	14%	14%	15%	15%

Table 2 : Assessment of the current international services in the Benelux

The differences between weighted and unweighted figures indicate that flows are relatively large on connections where the speed is relatively low, the detour is relatively large, and the number of transfers is relatively small. The average speed of 64 km/h when no high-speed services are used is really low for intercity connections, and due to the large average detour of 1.57 the speed is still significantly lower if the calculation is based on crow-fly distances. Inclusion of high-speed services raises the average speed, but 72 km/h is still low and the detour remains large.
One might ask oneself whether the findings describe normal qualities of intercity train services or that they are worse for international services compared to domestic services. Table 3 shows the same indicators for the services between the selected stations within the Netherlands.

Indicator	unweighted	weighted
Speed (crow-fly distance)	62	62
Speed (actual distance)	78	77
Detour	1.30	1.27
Service frequency	2.56	3.93
# of transfers per trip	0.89	0.28
Transfer time per trip	8.42	2.25
Distance between transfers	153	204
Share of transfer time	8%	5%

Table 3 : Assessment of the current services in the Netherlands

The design of the domestic services is more flow-based; significant differences between weighted and unweighted figures are in favour of the weighted ones.
The average speed of the domestic services is significantly higher than those for the international services, even if high-speed services are taken into account. The speed differences are even larger if they are based on crow-fly distances because the detours are substantially smaller for domestic travellers. The domestic quality is also much better for the other indicators: the service frequency is four times higher, the number of transfers per trip or per trip km is lower, and the share of transfer time is just a fraction of that for the international trips. The domestic services are apparently better interconnected than the international services.
The quality of the international services varies by trip type. Table 4 shows the weighted values for different distance classes (crow-fly) and demonstrates that with increasing distance

the speed increases, the detour decreases, the number of transfers per trip increases, and the distance between successive transfers increases.

Indicator		Excluding HST services		Including HST services	
	< 50 km	50-200 km	> 200 km	50-200 km	> 200 km
Speed (crow-fly distance)	36	46	50	53	56
Speed (actual distance)	53	66	68	77	80
Detour	1.73	1.55	1.35	1.57	1.43
Service frequency	0.92	0.97	0.96	0.86	0.75
# of transfers per trip	0.87	1.72	2.59	1.59	1.99
Transfer time per trip	13	23	37	22	34
Distance between transfers	68	103	130	114	179
Share of transfer time	19%	14%	12%	15%	13%

Table 4 : Weighted quality indicators for international connections by distance class

A good service quality is particularly important for connections between the largest cities. Table 5 shows the indicators for connections between large cities over 200,000 inhabitants (indicated by 1 or 2 in the classification column of Table 1) and connections between very large cities over 500,000 inhabitants (classified as 1). The quality increases indeed when the city size increase, and this is valid for all quality indicators except for the frequency. However, if no HST-services are used, the speed remains low and is even for the connections between the largest cities lower than the average for the domestic services in the Netherlands. Supply of HST services appears to be necessary to increase the speed to a significant higher level.

Indicator	Excluding HST services		Including HST services	
	Large cities	Very large cities	Large cities	Very large cities
Speed (crow-fly distance)	54	59	77	100
Speed (actual distance)	70	72	99	121
Detour	1.32	1.21	1.32	1.21
Service frequency	0.99	1.00	0.78	0.7
# of transfers per trip	0.85	0.27	0.85	0.30
Transfer time per trip	11	3.84	12	3.56
Distance between transfers	196	535	198	495
Share of transfer time	7%	3%	10%	4%

Table 5 : Weighted quality indicators for international connections between large cities

From December 2016 on, the regular train services between Amsterdam and Brussels will use the high-speed line between Rotterdam and Antwerp, though they will not run at high speed and will call at Breda what takes a lot of time. It is expected that the travel time will even be a few minutes longer (Ministerie van Infrastructuur en Milieu, 2013, answer on question 35). The main improvement is that Breda will be connected, though Dordrecht will not be connected anymore and Roosendaal loses its fast train connection with Antwerp, what has the consequence that the connections between Middelburg/Province of Zeeland and Belgian cities deteriorate.

Table 6 shows the indicators for the planned services and additionally those for the current services taken from Table 2. It demonstrates that there is hardly any change on the aggregate level of the indicators.

Indicator	Excluding HST services		Including HST services	
	Current services	Planned services	Current services	Planned services
Speed (crow-fly distance)	44	45	50	51
Speed (actual distance)	64	65	72	73
Detour	1.57	1.57	1.59	1.58
Service frequency	0.96	0.96	0.86	0.86
# of transfers per trip	1.64	1.55	1.48	1.39
Transfer time per trip	22	22	22	22
Distance between transfers	104	111	118	126
Share of transfer time	14%	14%	15%	15%

Table 6 : Assessment of the planned international services

Van Goeverden (2014) and Van Witsen (2011) argue that the regular train services between the largest cities in Western Holland and Central Belgium should not call at Breda and that additional services between Breda and Belgium using the high-speed line should be added. The Belgium to Breda services should preferable be extended behind Breda into the Netherlands to provide more direct connections with Dutch cities. Van Witsen suggest extension to ‘s-Hertogenbosch-Utrecht-Amsterdam, van Goeverden suggests extensions to ‘s-Hertogenbosch-Nijmegen-Arnhem and/or to Eindhoven.
In the paper, we assess next improvements:

- an hourly high speed service Amsterdam-Schiphol-Rotterdam-Antwerp-Brussels,
- an hourly high speed service The Hague-Rotterdam-Antwerp-Brussels airport-Brussels, providing each half hour a connection between Rotterdam and Antwerp/Brussels together with the services from Amsterdam,
- and an hourly service with normal trains Arnhem-Nijmegen-‘s-Hertogenbosch-Tilburg-Breda-Antwerp.

The high-speed services are operated under normal conditions, do not require seat reservation and have fares that are comparable to, but could be somewhat higher than, those of the regular intercity services.
In Table 7, including again the figures for the current services for comparability, the indicators describing the quality for this variant are displayed in the column with the heading “Breda corridor”. The most right column includes a proposed additional improvement in the second corridor with cross-border train services between the Netherlands and Belgium, between Maastricht and Liège. In the latter corridor runs a slow stopping train with bad connections in Maastricht and also in Liège to trains in some directions. We assess an additional faster intercity service running from Zwolle via Arnhem-Nijmegen-Venlo-Maastricht to Liège. This service uses the “Maaslijn” between Nijmegen and Roermond that is not designed as a main railway line, but fast train services on this line are planned in the future.

Indicator	Current services		Improved variants	
	Excl. HST services	Incl. HST services	Breda corridor	Breda and Maastricht corridors
Speed (crow-fly distance)	44	50	52	55
Speed (actual distance)	64	72	74	78
Detour	1.57	1.59	1.58	1.57
Service frequency	0.96	0.86	1.24	1.43
# of transfers per trip	1.64	1.48	1.42	1.35
Transfer time per trip	22	22	19	17
Distance between transfers	104	118	123	129
Share of transfer time	14%	15%	14%	13%

Table 7 : Assessment of the proposed improvements of the international services

The improvements in the Breda corridor increases the frequency significantly and give slightly higher qualities for the other variables, compared to the current services with usage of high-speed trains. Remarkably, the number of transfers decreases just a little, despite the added direct train connection between Arnhem and Antwerp, serving many other cities. The explanation is that on some connections more routes are included that sometimes have more transfers. An example is Amsterdam-Antwerp. In the current situation, using high-speed trains, there is a direct train service with no good alternative and no transfers are assumed. In the proposed improvements, a high-speed service The Hague-Belgium is added connecting in Rotterdam to trains from Amsterdam. Then there is a good alternative for the direct connection Amsterdam-Antwerp, but this requires a transfer in Rotterdam. For this kind of connections with alternating direct services and services with one transfer we assume the average of 0.5 transfers. The result is that the number of transfers increases by adding more services. This increase counteracts the decrease induced by more direct connections.
The additional train in the Maastricht-corridor has a relatively large impact. It increases the speed and frequency and lowers the number of transfers somewhat. Still, the speed remains low and below the domestic average.

4. Conclusions

Generally, cross-border train services have a lower quality and are less stable over time than domestic services. The analysis of the paper shows that a relative low overall quality is also valid for the cross-border intercity train services in the Benelux. The relative low quality regards all assessed variables: speed, detour, frequency and transfers. A good integration of timetables for the networks of neighbouring countries and addition of direct international train services on longer distances might enhance the quality for cross-border travelling. The development of standards for required quality might encourage operators to improve their services, while authorities could use them for defining regulations in concessions.

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