ERASMUS UNIVERSITY ROTTERDAM
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Intermodal competition between air and rail

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Abstract

This paper examines intermodal competition between air travel and (high speed) rail. Three methods are used: literature review, ex-post empirical evidence and a survey.

Literature research shows that air travel and rail travel are substitutes on distances greater than 200 kilometres. How long it takes to cover a certain distance by train is highly dependent on geography and the available infrastructure. Most people who travel by train do so because it is fastest, price seems to be less important to them. High-speed trains therefore compete mostly with full-service airlines; Low-cost carriers serve a different segment of the market.

The empirical model developed in this paper shows that, as travel time by train gets lower, market share increases by around 0,3% per minute of travel time by train. When travel time by train is around 4 hours, both modes of transport capture roughly half of the market. It seems that this is longer than it was before.

The case study conducted focussed on the recently introduced Eurostar service between Rotterdam and London and its competition with British Airways' flight between Rotterdam and the London City airport. A survey was conducted among 24 customers of the flight to London. The results show that the majority of them are business travellers and that time is the most important factor in choosing the plane for those business travellers. Leisure travellers on the other hand indicate that price is the most important factor for them. Research also shows that al lot of passengers of the Rotterdam-London flight would consider taking the plane in the future.

Table of contents

1. Introduction

There is an effort underway to shift our economies away from fossil fuels towards renewables in order to decrease the amount of greenhouse gas emissions. Slightly over a quarter of green house gas emissions in the European Union (EU) is from transportation (European Environmental Agency, 2017). Aviation contributes 13,3 percent of these emissions, rail travel 0,5%. Aviation is very polluting compared to other modes of transportation, rail travel in particular (CE Delft, 2003). It should be noted that there is a scientific debate about the life-time emissions of (high speed) rail; the total emissions when construction of infrastructure and vehicles is included (Chester & Horvath, 2009). We can, however, be sure that the marginal emissions of rail travel are much lower than those of air travel. A shift away from aviation towards rail travel would therefore be beneficial to the environment.

1.1. Research question

This paper will examine the intermodal competition between rail travel and air travel. It will investigate under what conditions planes and trains can compete and what factors are (most) important for people when deciding between the two modes of transport.

The research question is formulated as follows:

Which factors influence the competition between train and plane and how?

1.2. Research methods

To answer this question a more general question has to be answered first: what factors influence the choice between different modes of transportation in general? Through literature research this question in general and for rail/air transportation in particular will be answered.

1.2.1. Empirical model

In order to examine the subject empirically, data was collected on market share and travel time of rail and air on selected routes. A model was then developed to examine the relationship between travel time and market share for the two modes of transport.

1.2.2. Case-study

Lastly, a case study was conducted for the Rotterdam-London market, where a direct train service has been introduced recently (for the time being only one-way). A survey was conducted at the Rotterdam airport among travellers taking the direct Rotterdam-London flight in order to illustrate how travellers make their mode-choice on this specific route and in general.

1.3. Definitions

Long distance travel: No general definition for long distance travel exists, many statistical organisations use 100 kilometres or more as a definition for long distance (Limtanakool, Dijst, & Schwanen, 2006), others define long distance travel by the purpose of the trip, or the duration of stay at the destination (Frei, Kuhnimhof, & Axhausen, 2010). For the purpose of this paper, trips that are made by airplane are considered long distance. The nearest destinations from the Amsterdam airport with regular scheduled service are Brussels and Düsseldorf, both slightly over 200 kilometres over the road. For this research, trips over 200 kilometres are therefore considered long distance. Moreover, Cascetta, Coppola and Velardi (2013) also concluded that high speed rail is mainly a substitute for car travel on distances between 100-250 kilometres, and not for air travel. The upper bound in this research is the distance that can be travelled by a train in a day as longer direct train services are extremely rare in Europe.

Door-to-door travel time: time spent travelling from origin to destination, includes in-vehicle time and ingress-egress time. The latter is independent of trip length and general longer for air travel than for rail travel due to the fact that airports are located outside the city and check in takes a considerable amount of time. The former is always longer for trains than for planes and increases more with distance for rail travel compared to air travel. For rail travel, travel time is also dependent on the route taken by the train and whether the train is a high-speed train or a conventional train. Transfer time is also part of door-to-door travel time.

High speed train (HST): train capable of travelling over dedicated high speed railway lines (HSRs) at 250 km/h or more and/or conventional lines at 200 km/h or more (Union Internationale des chemins fer, 2018).

1.4. Reading guide

Firstly, previous research on the subject will be presented and analysed ending with a partial conclusion. Next the methods used for developing the time/market share model will be explained, followed by the results and another partial conclusion. The part covering the survey is divided into methodology, data and results. The last section is the general conclusion including a discussion and some policy recommendations for the relevant actors.

2. Literature review

Firstly, various mode-choice models must be examined and a relevant one must be chosen for this research. Most of the research concerning choice of transport mode focusses on commuting; short distance travel where the power of habit plays a very important role. Verplanken, Aarts, & Knippenberg (1994) showed that choice of transportation mode is dependent on the attitude towards that mode of transport relative to alternatives, and on habit. The question is whether the second factor, habit, is as important when deciding which mode to take when travelling long distance as it is when commuting. Long distance travel is usually done less frequent and is being planned carefully. It is therefore likely that long-distance travel decisions are less habitual.

2.1. Factors

That people choose a mode of transport based on their attitude towards that mode relative to alternative is of course logical. The question is what factors influence that attitude? The most important factors identified in previous research are price, frequency and time, with time often divided into in-vehicle time and out-of-vehicle time or similar terms (Brat, 1995; Yao & Morikawa, 2005; Bhat, 1998).

2.1.1. Distance and time

It is important to determine under what conditions air travel and rail travel compete with each other. According to a report prepared for the Commission for Integrated Transport in the United Kingdom, (high speed) rail is generally competitive over the distances shown in Figure 1 (Steer Davies Gleave, 2004). The European Commission (EC) used the same figure in one of its publications (European Commission, 2010).

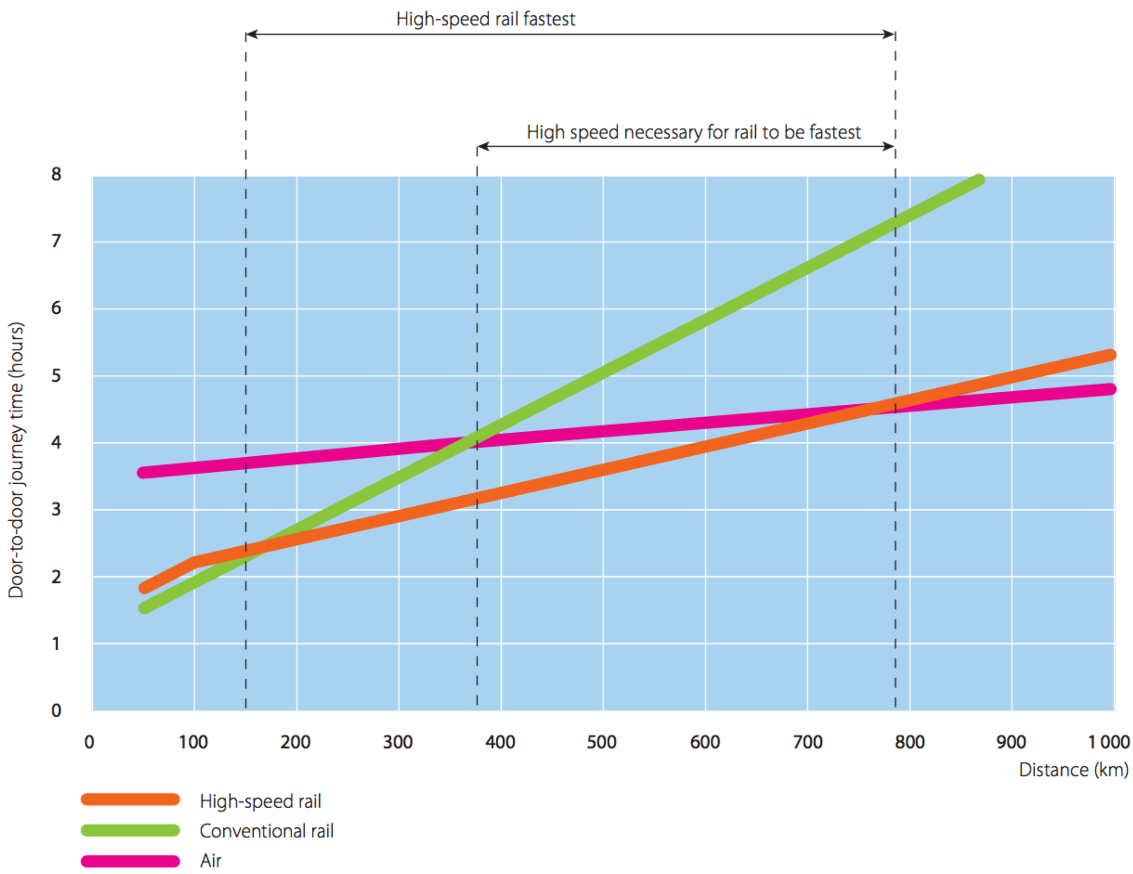

Figure 1: Journey times v. distance for rail (HSR and conventional lines) and air transport (source: European Commission, 2010).

The point in Figure 1 where the lines cross the Y-axis is ingress-egress time/out-of-vehicle time. According to this author that time is on average 3,5 hours for planes and around an hour for trains (slightly longer for HSTs). HSTs need a long stretch of railway line to reach their top speed which is why they are not necessarily faster than conventional trains on short distances, they stop at fewer stations which is why some passengers have to travel longer to board an HST and average ingress-egress time is higher. According to this graph, planes are on average faster than trains on distances over 800 kilometres (slightly under 400 kilometres if HSTs are not available). We have to bear in mind that these are averages; how long a train takes to travel a given distance is dependent on numerous factors. Planes do not need dedicated infrastructure between take of and landing, can almost always take a direct route and make no intermediate stops. This means that the relationship between distance and time is relatively constant. The location and accessibility of the airport does matter of course for the out-of-vehicle time.

That a certain mode of transport is faster on a given route does of course not mean that the other mode cannot compete. When the other mode is cheaper, more comfortable or offers other benefits, it is still possible to compete despite being slower.

2.1.2. Time and market share

The relevant factor for consumers is of course not the distance in kilometres but the time it takes to travel from origin to destination. Previous researchers (López-Pita & Robusté, 2005) have concluded that there is a steep drop in market share and that this drop occurs around a travel time of three hours by train. Jorritsma (2009) used the following formula to describe the relationship between market share and travel time: $s=1/(0{,}031*1{,}016^{t}+1)$ meaning that rail captures half of the market when travel time is aproximately 220 minutes (slightly over 3,5 hours). Givoni and Dobruszkes (2013) found 3,5 hours to be the point where rail captures half of the market. In a recent study, the *Kennisinstituut voor mobiliteitsbeleid* (2018)[1], developed a model where the relationship between time and HST market share was described by the formula $s=1/(1+e^{0{,}01897t-4{,}015})$. This model yields a 50% market share for both modes at around 220 minutes of travel time. See section 3 for the model developed by this paper.

2.1.2.1. Time: in-vehicle vs. door-to-door

The question arises whether people make their decision based on door-to-door travel time alone, or do they treat in-vehicle time differently from ingress-egress time. Algers (1993) found that train in-vehicle time seems to be less onerous than in-vehicle time for other transport modes modes. Givoni and Dobruszkes (2013) concluded that door-to-door travel time and its quality, not station-to-station or airport-to-airport travel time, are important in mode choice. This might seem logical but it is worth noting that, while consumers have near-perfect information about the in-vehicle travel time (they can look at the schedule), they have less perfect information on ingress-egress time.

2.1.3. Price and Time

How sensitive are people to time increases and towards increases in price, how much are they willing to pay for a shorter journey? Steer Davies Gleave (2006) conducted a series of case studies and concluded that travel time explains 84% of the difference in market share of rail compared to air on eight different routes (and thus is much more important than price). Coto-Millán, Inglada, and Rey (2007) found that the main reasons for the use of the HSR according to users are comfort (29%) and time (30%) both quite a lot more important than price (11%) the main reasons for the use of the plane are comfort (31%), price (19%), speed (13%), novelty (11%) and safety (6%). Behrens and Pels (2009) concluded that HSR passengers are less sensitive to frequencies, fares and total travel time than airline passengers. This is why low cost carriers (LCC) have not had a serious impact on passenger numbers for HSR. Friebel

[1] Data used is from 2010 and 2013 papers

& Niffka (2005) also support the conclusion that the market share of LCCs is ‘stolen’ from full-service airlines (FSA), not HSTs. Román, Espino and Martín (2010) analyzed competition between the HST and the plane on the Madrid-Barcelona corridor, one of the busiest air routes in the world (at least before introduction of HSTs). They found that demand for HST is inelastic to price, time and especially to headway. In the case of competition between HST and air transport in the Madrid-Barcelona corridor, they showed that HST demand is more sensitive to air travel cost and ingress-egress times

Altogether we can therefore conclude that time is the crucial factor for people travelling by HST. In order to attract passengers from other forms of transport, most notably LCCs, it will have to focus on other factors. Low-cost trains have been introduced in (amongst others) France (Ouigo) and Germany (Flixtrain), unfortunately there is no available scientific research into their performance yet.

2.1.4. Segments and Class of travel

What mode people choose for travelling is not only dependent on the characteristics of that mode but also on the type of traveller. Travellers can be divided by socio-economic factors and by trip purpose (business or leisure). By examining the London-Paris route, Behrens and Pels (2012) found that business travelers value time higher than leisure travelers and that, contrary to what they expected, leisure travellers are more sensitive to frequency and travel time. HSR’s market share is much higher in the leisure segment than in the business segment. Ivaldi and Vibes (2005) underwrite this conclusion based on research in the German market, they concluded that business passengers have a higher valuation for speed than leisure passengers. Also, business travelers are almost indifferent to frequency improvements of train services. Gonzales-Savignat (2004) found that those travelling for work (with their employers paying) assign less importance to cost and more to time, those that are self-employed assign higher disutility to travel cost. Travellers travelling more frequently derive higher disutility from access time and higher utility from service frequency. Whether people travel alone or in a group also matters, cost is a more important factor for people travelling as part of a group. Altogheter, Gonzales-Savignat concludes that segmentation between business and leisure trips is most suitable, yielding the most heterogenity. Algers (1993) distinguished between ‘full time salaried employees’ and others and found that the former have higher values of time.

2.2. Other relevant findings

Behrens and Pels (2012) looked into the competition between the HST and the plane on the London to Paris route, one of the most heavily traficked routes in Europe. They identify three kinds of suppliers: FSA, LCC and the HST (Eurostar). travellers are more sensitive to frequency and travel time. Most importantly, they found that cross elasticities between rail and air travel (both FSA and LCC) are high in this market which means that intermodal competition is strong.

Dobruszkes (2011) took a supply-oriented perspective. Looking at four cases he found that: 1) The introduction of HST services has led to a complete discontinuation of air services on the Paris-Metz/Nancy route. 2) On the Paris-Brussels route, the introduction of HST services has led to near-complete discontinuation of air services. 3) The introduction of HST services has led to a major decline in air services between Brussels and London. 4) In the Paris-Marseille market, the reduction in seats is greater than the reduction in flights (meaning the airlines have chosen to focus on offering frequency in order to compete). These findings are clear evidence that HSR is an important substitute for air travel, and that travel time is a crucial factor. Other authors also conclude that airlines often increase frequency on routes where they have to compete with HSTs, even if the total number of seats decreases (Albalate, Bel and Fageda, 2015)

Givoni and Dobruszkes (2013) looked into 'the level and nature of mode substitution and induced demand' for new HSR services. They found that most of the demand for HSR services (75–90%) is demand shifted form other transport modes (all modes, not only air). Conventional rail is the most important 'mode of origin' for HSR (albeit not being a real change of mode). Second and third are air and road transport. Mode substitution to HSR from bus services appears to be modest. On average 20% is induced demand, demand that did not exist prior to the introduction of HSR service. It should be noted that effects vary greatly across different routes in different countries and continents.

2.3. Concluding

Figure 2 shows how the factors interact, travel mode (conventional train, HST or plane) together with distance determines travel time. Travel time in turn is the most important factor in explaining why people choose rail travel over air travel, along with price and other factors. Travel time is the most important factor according to scientific literature.

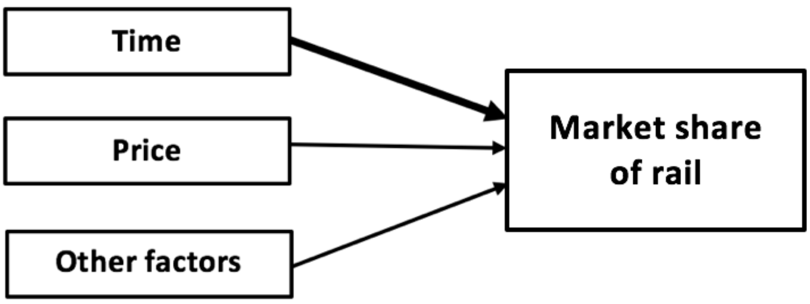

Figure 2: diagram of the interactions between the relevant factors

3. Market share model

Previous research has shown that the point at which the market shares of rail and air are both 50% is around 3 to 3,5 hours travel time by train. In order to determine whether this is (still) the case, a model was created.

3.1. Methodology and Data

Data was collected on two variables: travel time between city-pairs and the market share of the train and the plane on that route. Only rail and air are considered, the market share of these two modes together is thus always 100%. The data on market-share was collected from multiple sources:

- Research publications
- Annual reports of railway companies
- News articles

All figures that could be found are included, as long as the information was not older than 10 years. When multiple figures existed for the same city-pair, the most recent figures were used. Also, it was made sure that the the travel time on the relevant routes had not changed significantly between the date of the figures and the present day. In some cases the market share of more modes than just air and rail was reported, in these cases the market shares of the two relevant modes were converted so as to add up to 100%.

In order to determine the travel time, the travel planner of the relevant railway company was consulted. The figure for the fastest journey available was used.

Table 1 shows the in-vehicle travel time and market share of rail (relative to air travel) of 29 city-pairs (non-European city-pairs are coloured: red for Japan, blue for the USA). See Appendix 7.1 for the sources of the data on the market shares and information on distance and speed (where available).

Table 1: Distance and market share of selected city-pairs

City-pair	Time (min)	Market share Train (%)	City-pair	Time (min)	Market share Train (%)
Tokyo - Nagoya	100	100	Rome - Milan	160	64
Brussels - Paris	82	96	Madrid - Barcelona	150	63
Paris - Lyon	117	90	Paris - Marseilles	183	60
Brussels - London	121	85	Paris - Basel	212	60
Tokyo - Osaka	155	85	Stockholm - Gothenburg	233	60
Madrid - Sevilla	140	84	Amsterdam - Frankfurt	235	60
Amsterdam - Cologne	158	84	Paris - Geneva	188	54
Paris - Bordeaux	124	82	New York - Boston	240	54
Paris - London	136	81	Stockholm - Malmö	263	40
Rome - Bologna	123	75	Paris - Nice	345	38
New York - Washington DC	178	75	London - Edinburgh	257	33
Amsterdam - Paris	198	70	Paris - Frankfurt	218	31
Tokyo - Okayama	210	69	London - Glasgow	269	27
Tokyo - Hiroshima	241	67	Tokyo - Fukuoka	356	10
Paris - Stuttgart	189	66			

3.2. Results

Figure 3 shows the plot of the travel time and market share of the train of all observations (market share of the plane is 100% minus the market share of the train). It is clear that as travel time by train increases, the share of traffic by rail decreases.

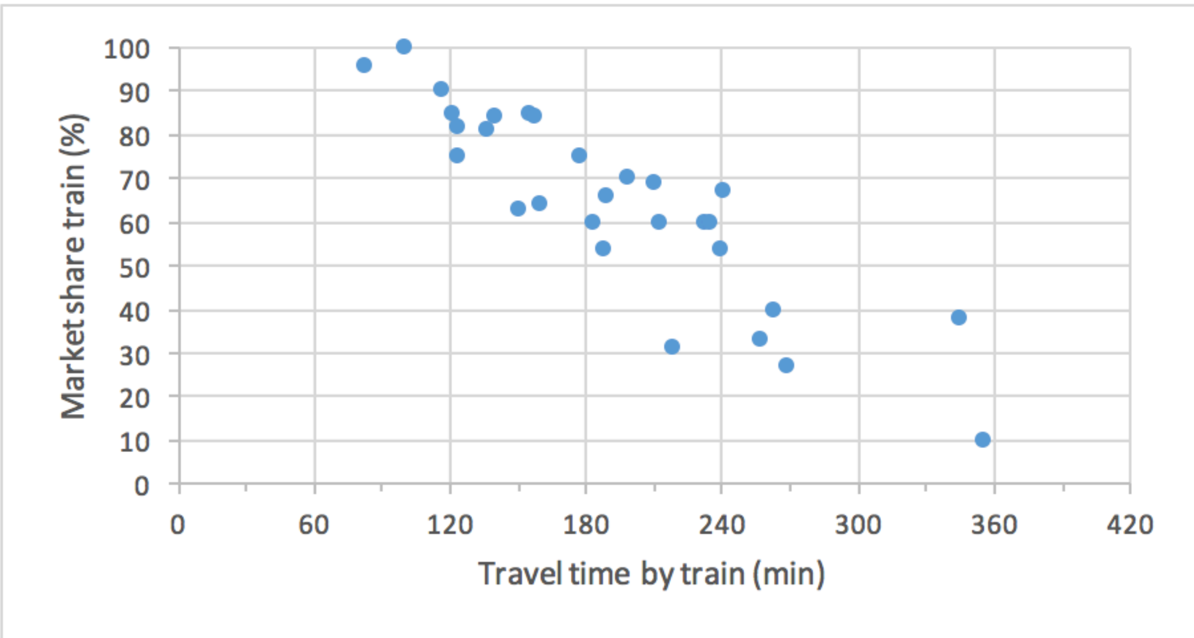

Figure 3: Travel time and market share of the train and plane.

The best-fitting relationship is a linear relationship, which gives us the following formula:

$$\textit{Market share} = \alpha * \textit{travel time} + \beta$$

Table 2 shows the coefficients for the model. When travel time by train is less than 100 minutes, virtually no-one travels by plane. When travel time is around 4 hours (242 minutes), roughly half of the people travel by rail. The fact that the relationship is linear tells us that in-vehicle travel time is not the only factor affecting market share. If it was, the market share of rail would be close to 100% up to a certain point (the point where the plane is faster) and then drop very fast until the market share of air travel is close to hundred percent, this does not seem to be the case. Whether there is a (small) drop around four hours travel time is impossible to tell because there are too few observations on routes with travel times over four hours.

Table 2: Model for relationship market share and travel time by train

	Coefficient
α (travel time by train in minutes)	-0,2879
β (Constant)	119,65
R^2	0,7838

While it appears that market shares of rail are higher in Japan and the USA (travel time being equal), there is not enough data to determine for sure if this is indeed the case.

3.3. Concluding

A increase in travel time by train decreases the train's market share by approximately 0,3%. Both modes of transport capture half the market when travel time by train is 4 hours. This is notably longer than previous research showed (see Table 3). It is possible that the point where air has a higher market share than rail has shifted because (the burden of) out-of-vehicle time has increased for air travel over time relative to rail travel. Congestion at airports may also be a factor. The model in this paper describes a linear relationship while some other researchers found other relationships to be better-fitting. The data used for this model is not only younger, the model is also based on more observations than the other models.

Table 3: Travel time where market share is 50% for both modes by author and year.

Author(s)	López-Pita & Robusté	Jorritsma	Givoni and Dobruszkes	Kennisinstituut voor mobiliteitsbeleid	*This research*
Year of data	Pre 2005	Pre 2009	2000-2010	Pre 2013	*2009-2018*
50% market share (min)	180	220	210	220	*240*

4. Case Study: The Rotterdam-London market

4.1. Situation sketch

London is by far the busiest destination served from Rotterdam The Hague Airport (RTM)[2]. British Airways (BA) offers 7 return flights daily to London City Airport (LCY) on most weekdays (6 on Fridays, 2 over the weekend as a whole)[3], journey time is 55 minutes. The total amount of passengers flying to London from Rotterdam was 219.222 in 2016[4]. As of 2018, Eurostar operates direct high speed trains from London (St. Pancras railway station) to Rotterdam (Central Station) with an intermediate stop in Brussels. These trains operate twice daily and reach Rotterdam in 3.01 hours[5]. On the return leg however, there are no direct trains and passengers have to change at Brussels (Southern railway station). The fastest Rotterdam-London journeys take 3.59 hours[3]. It is expected that direct Rotterdam-London trains will operate in the future with a similar journey time as the London-Rotterdam services.

While the train takes 3 times as long on the London-Rotterdam leg, and 4 times as long on the return, the train has the advantage of departing in the city centre. The average out-of vehicle times for this route are slightly different than for other routes for a few reasons: Check-in and immigration is required for the train (at London St. Pancras) taking 30-45 minutes for 2nd class passengers and 10 minutes for 1st class passengers[6]. On the journey to London, immigration is cleared in Brussels. Out-of vehicle time for the train is thus higher than average for rail travel.

Out-of-vehicle time for the plane on the other hand, is lower than average. The airports in Rotterdam and London are both small (leading to short transit times) and located close to the city-centre. Both are reachable by metro. According to Google Maps, it takes half an hour to reach the city centre of Rotterdam (City Hall) from the airport by public transport. LCY to the centre of London (Piccadilly Circus) takes 35 minutes by public transport. A journey from the relevant railway station to the same places takes 12 minutes in London and 2 minutes in Rotterdam. What the total journey time is, is of course highly dependent on the origin and destination.

4.2. Methodology

In order to determine how travellers choose, it was first necessary to determine what they knew about the options available to them. Therefore, respondents were asked

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[2] Jaarverslag 2017 Rotterdam The Hague Airport (https://www.rotterdamthehagueairport.nl/content/uploads/2018/07/feiten-en-cijfers-2017.pdf)
[3] Source: https://www.britishairways.com/travel/schedules/public/en_gb
[4] Source: http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do
[5] https://booking.eurostar.com/nl
[6] https://www.eurostar.com/nl-nl/reisinformatie/je-reis/inchecken

whether they knew about the existence of the Eurostar service between Rotterdam and London and how long they think it would take to travel by train. Next they were asked what the most important factor was for them to choose the train. In addition, there were questions in the survey about the nature of the trip and the demographic characteristics of the respondents.

The survey (see Appendix 7.2) was conducted at four different moments during the last week of September 2018, 33 people responded, 24 of whom flew to London:

24-09-2018, 15.45: surveys number 1-3
26-09-2018, 10.55: surveys number 4-11
26-09-2018, 15.45: surveys number 12-15
28-09-2018, 10.55: surveys number 16-24

I arrived at the airport approximately 2 hours before departure. For the afternoon flight I positioned myself near the check-in counters of the flight to London, for the morning flight I positioned myself by the entrance to the security check. The reason for this is that the 10.55 flight to LCY was the only flight leaving around that time meaning that almost all passengers who went through security flew to London (on top of that it was calm, meaning that I could approach virtually every single passenger walking towards the security check). The 15.45 flight on the other hand departed at a busier time for the airport meaning there was a line for security consisting mostly of people flying to destinations other than LCY. I could not approach all passengers which meant that I would have to choose which passengers to approach. This would mean making assumptions (consciously or subconsciously) about which traveller looked like a 'London traveller', creating a bias in my sample. Therefore, I decided to position myself near the check-in counters of BA to avoid having to choose which passenger to interview. Not all passengers check-in at the airport of course so positioning myself in this way creates a bias too, but I felt this was less problematic than the other option because this bias was not caused by the imposition of my values/assumptions. As shown above, there were more respondents in the afternoon (when standing near security) than in the morning.

The survey was abandoned as soon as the information screens indicated that the flight was boarding, almost no-one would be willing to spare a few minutes to answer a survey at this point in time.

4.3. Data

The raw data (Appendix 7.3.1) was treated so it could be processed. Numeric values were grouped into intervals, for Question 4 the intervals <1, 2-4, 5-6, 7-9 and 10+ were chosen. This way, the intervals are not too large and the same size. People who flew very frequently and those who flew rarely were given special categories (0-1 and 10+).

The answers to Question 7 were divided into correct answers (3-4 hours), too low estimates (<3 hours) and too high estimates (>4 hours).

For Question 14 (age), it was decided to use intervals of 10 years, as is common.

It was possible to answer something else than the default options for Question 12. Two respondents filled in 'Convenience' and one '*Makkelijk*' which, in this context, translates to 'Convenience'. It was therefore decided to add 'Convenience' as an answer as it was a more popular answer than some of the default options. Other fill-ins are marked as 'Other' so there is a distinction with 'Convenience' (both are marked 'E' in the raw data)

The treated data is shown in Appendix 7.3.2. We see that there is one missing value (Survey 9, Question 6), and that there are two irregular answers (Survey 3, Question 12 & Survey 10, Question 12). These answers were irregular because a combination of two factors was chosen instead of one individual factor. Because it is impossible to make assumptions about how these two factors should each be weighed and as it is not possible to double-count, these irregular answers were lumped together with 'Other' to form 'Other/Combination'.

The figures below give an overview of the most important demographic characteristics of the sample population. Appendix 7.4.1 shows that roughly half of the respondents are men, and the other half are women. The vast majority of the respondents were business travellers (Appendix 7.4.2), the respondents were slightly more likely to be business travellers that the average passenger on this route (63% against 54%[7]), indicating a slight bias in the sample. Just one passenger indicated that she usually travels business class, as Appendix 7.4.3 indicates. More than half of the respondents were members of BA's frequent-flyer program (Appendix 7.4.4).

Half of the respondents lived in the Netherlands, slightly over 40% in Britain and a few somewhere else in the world (Appendix 7.4.5). Of the British residents, the majority lived in London, whereas just around a third of the respondents living in the Netherlands reside in Rotterdam (nobody lives in the Greater London area). Appendix 7.4.6 shows what age category the respondents belong to. How frequently respondents fly between Rotterdam and London is shown in Appendix 7.4.7, please note that three quarters of the respondents fly this route once a year or more.

[7] Jaarverslag 2017 Rotterdam The Hague Airport (https://www.rotterdamthehagueairport.nl/content/uploads/2018/07/feiten-en-cijfers-2017.pdf)

4.4. Results

4.4.1. Most important Factor

Figure 4 shows what correspondents themselves indicate as being the most important factor for choosing the plane. Almost half of the people who responded said time was the most important factor for choosing the plane. Respondents are significantly more likely to indicate that time is the most important factor compared to the other factors. As Figure 5 shows, business travellers are more likely to indicate that time is the most important factor, whereas leisure travellers are much more likely to consider price the most important factor. Frequency of travel is of course closely related to purpose of travel, that's why we see a strong (actually more significant) relationship with the factor time (see appendix7.5). Interestingly, whether a respondent is a frequent flyer does not seem to matter at all (see appendix 7.6). Gender is of no influence either. For Age it is difficult to make observations as the individual groups are small and the relationship is unclear[8].

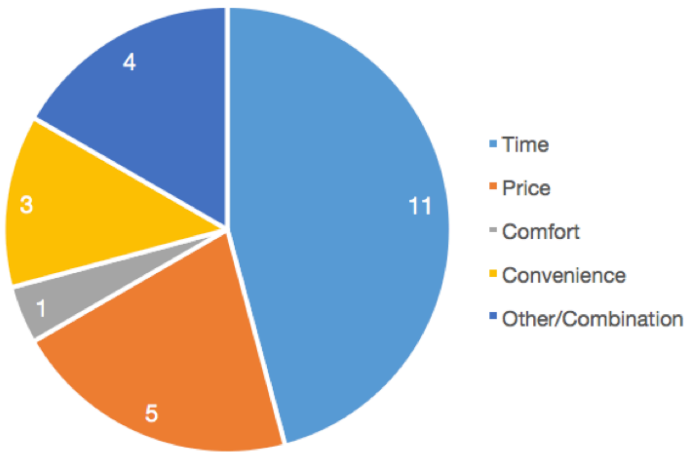

Figure 4: Most important factor

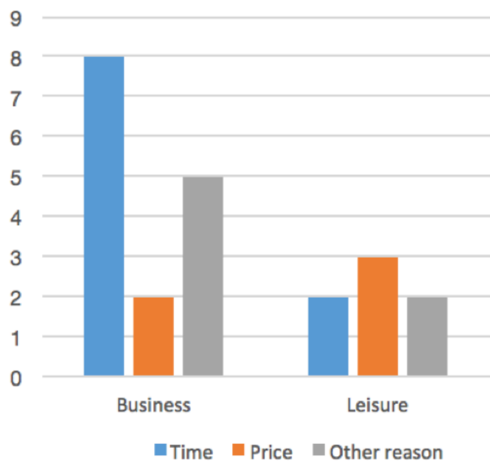

Figure 5: Most important factor for different sorts of travellers

4.4.2. Estimations

Respondents who had not yet travelled by train between Rotterdam and London (21 respondents) were also asked how long they thought the journey by train would take. As Figure 6 shows, almost half of the respondents had a correct estimation of the travel time. In combination with Question 8 (Would you take the train now you know how long it takes) it is possible to determine whether people who thought the train ride takes longer were more inclined to take the train in the future now they know it is faster than expected. Curiously, the results do not show that those estimating the

[8] For groups of more people, only the age of the respondent was written down although purpose of travel was probably the same for all group member

journey to be longer are more inclined to consider taking the train in the future, to the contrary, people estimating the journey to be longer than four hours are much less likely to consider taking the train after being told it is faster then they thought.

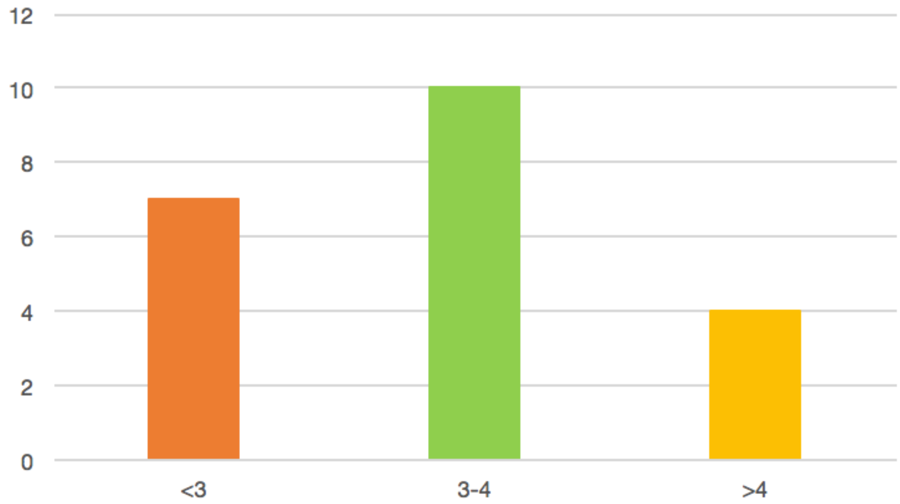

Figure 6: estimations of travel time

4.4.3. Would you travel by train in future?

As Figure 7 shows, 19 respondents had either taken the train or would (under circumstances) consider taking it in the future. Of the respondents who indicated they would not consider taking it or answered they didn't know whether they would take the train in the future, almost half indicated they would consider taking the train when it is faster in the future. Also, two-thirds of those who indicated they would consider taking the train (or took the train already in the past), indicated that they would take it more often when the train is faster. That ridership will increase as soon as the service becomes direct both ways is almost certain, how much (more) people would switch is impossible to tell on the basis of this sample. The situation is too hypothetic to treat the responses as a reliable prediction. It should be noted that Eurostar is planning to introduce more services as soon as the authorities permit direct service both ways[9].

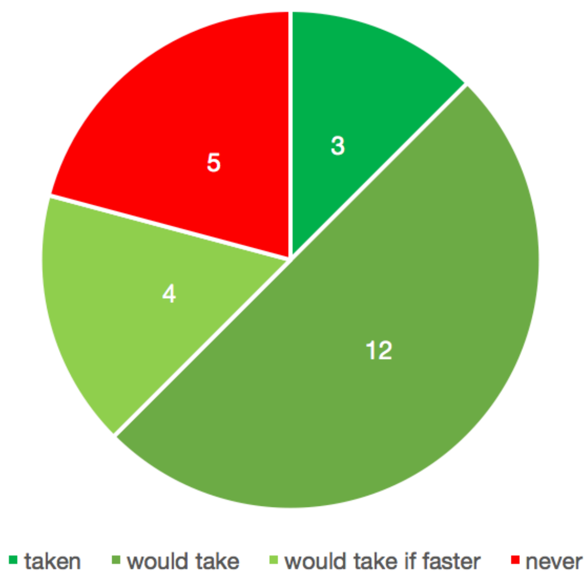

Figure 7: would you take the train?

[9] https://www.independent.co.uk/travel/news-and-advice/eurostar-london-amsterdam-trains-route-tickets-more-a8598781.html

According to the model in section 3, market share on this route (travel time of 3 hours) should be around 70%, perhaps a bit less due to the check-in required on routes to the UK. 79% of respondents indicate that they would consider taking the train as soon as it is direct in both directions. This is more than the model predicts, but as ‘consider taking the train’ does not mean every respondent will take the train every time, this figure is not necessarily out of line.

4.4.4. Other results

Six interviewees did not know about the existence of the Rotterdam to London train service, half of them would consider taking the train in the future.

5. Conclusion & Discussion

5.1. Conclusion

Which factors influence the competition between train and plane and how? First of all, it is possible to conclude that rail travel and air travel do indeed compete with one another. The point below which rail captures (and above which air captures) most of the market is around 4 hours travel time by train, market share changes with 0,3% per minute travel time by train. It appears that the point where both modes capture 50% of the market has gone up somewhat over time but further research would be needed to be sure. In the Rotterdam market this competition exists too as evidenced by the fact that around 80% of those flying between Rotterdam and London would consider taking the train instead of the plane now or in the future. How many of those people will actually take the train at some point in the future, and under which circumstances, cannot be predicted with certainty. When considering the travel time of 3 hours, it should be somewhere around 70% (Perhaps a bit less due to the check-in required on routes to the UK).

Of all factors that influence a travel-mode decision, time is the most important for travellers, the survey supports this finding. That time is much more important (relative to price) for business travellers compared to those travelling for leisure is also consistent with earlier findings. The importance of time for respondents is also closely linked to their frequency of travel. Please take into account that the sample-size is too small to draw scientifically valid conclusions, the results of the survey are illustrative.

The literature review also revealed that (high speed) train services mostly compete with FSAs; LCCs seem to serve a different segment of the market. This makes sense when considering that time, not price, is the crucial factor for railway customers. It should be interesting to see whether low-cost railway services will be able to take away some market share from LCCs in the future.

When asked, almost half of the respondents gave a correct estimate of the travel time on the service between Rotterdam and London, others were usually not very far off. This is a relevant finding because it means people do not make their decision on the basis of inaccurate assumptions and none of the travel modes is at a disadvantage because of it. Those who assumed that the train was slower than it actually is were significantly less likely to consider taking the train. It is impossible to know for certain why this is but perhaps these people carry a strong bias against rail travel.

5.2. Policy recommendation

Rail is a heavily regulated industry, improvements will therefore have to be initiated by governments, both national and European. Firstly, governments should not implement unnecessary obstructions such as security checks for trains[10] (and if they mandate it, make sure it is actually in place). The nature of rail transport makes deregulation and free competition hard to implement, nonetheless, governments should not obstruct operators (private, foreign or both) from offering services.

The existence of externalities (relatively more positive for rail transport), could justify the use of Pigouvian taxes to reduce the price of rail travel vis-à-vis air travel. Whatever people's stated motivations, virtually no-one is insensitive to price; lower relative prices will therefore cause more people to choose rail over air. The receipts of these taxes could also be used to invest in better rail infrastructure, making rail travel faster and thereby enticing even more people to choose rail. The model developed in this paper suggests that any reduction in travel time leads to a similar increase in market share for the train, focus therefore should be on improving the most travelled city-pairs and on the cheapest improvements. The travel time after reduction is not relevant, there does not seem to be a threshold that needs to be crossed.

A quarter of the respondents did not know yet about the existence of the Rotterdam-London Eurostar service. Eurostar could therefore do more to raise awareness. A lot of the media attention around the time of launch focussed on Amsterdam as a destination, not everyone may have realised that the train stops in Rotterdam too.

5.3. Discussion

The model developed in Section 3 was based on a lot of observations of city-pairs with a travel time of under 4 hours, the amount of observations of longer routes was smaller and the observations were more scattered. Whether the same relationship between time and market share is observed on these longer distances is therefore not certain. Further research would be needed to determine this.

Further research could also attempt to quantify the relationships this paper (and other papers) has proven to exist. Especially calculating price-elasticity and cross-elasticity of demand would be interesting. Research into reginal/cultural differences could also be relevant: all things being equal, do Europeans, Chinese and Americans like rail

[10] The checks also carry an advantage: Local governments often lobby successfully for international services to stop in their area causing HSTs to be unnecessarily slow. Building and staffing check-in facilities is expensive, therefore they only get build at the most important railway stations. This makes that Eurostar services stop less, in turn making them faster (Eurostar only stops once between Amsterdam and Brussels, Thalys trice).

travel equally well? Is there a difference between the formerly socialist countries of Eastern Europe and the market-economies of the West? This research has found some evidence that market shares are higher in Japan and the USA but could not prove this. If this were proven to be the case, what is the reason for these higher market shares; higher air fares/lower rail fares, or something else?

Lastly we should not forget that air and rail are not the only modes of transport available. The automobile is of course an important alternative and so are busses and other modes of transport.

As for the survey, 24 observations is too small a sample to draw scientifically valid conclusions, it can however serve to illustrate the evidence presented in this paper in a relevant example. The sample was not big enough due to the limitations in time and other resources.

A sample population virtually always has a bias, this one should be no different. The measures taken in order to avoid the avoidable biases have been described in section 4.2. The only characteristic of the sample that could be compared to the total population was the percentage of people flying for business, which was higher but not very different. It should be noted that we do not know how the airport came to their figure; their sample could be as biased as this one.

Secondly this case-study was done on the basis of stated preferences of respondents, it goes without saying that people do not always act like they claim to do, or reveal their real preferences. It should be interesting to compare the actual market share the Eurostar will attain on this route when the service is mature and whether BA will be forced to reduce flights.

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7. Appendix

Appendix 7.1: Travel time and market share

Time (min)	Market share Train (%)	Distance (km)	Avg. speed (km/h)	Route	Year	Source for market share
00	100	366	220	Tokyo - Nagoya	2016	http://english.jr-central.co.jp/company/ir/annualreport/_pdf/annualreport2016.pdf
2	96	312	228	Brussels - Paris	2009	https://www.vialibre-ffe.com/PDF/4509_AVE_UIC.pdf
17	90	429	220	Paris - Lyon	2014	http://www.cer.be/sites/default/files/publication/The_Economic_Footprint_-_web_-_final_final_30_Sept_0.pdf
21	85	373	185	Brussels - London	2010	https://www-tandfonline-com.eur.idm.oclc.org/doi/pdf/10.1080/01441647.2013.853707?needAccess=true
55	85	553	214	Tokyo - Osaka	2016	http://english.jr-central.co.jp/company/ir/annualreport/_pdf/annualreport2016.pdf
40	84	470	201	Madrid - Sevilla	2009	https://www.vialibre-ffe.com/PDF/4509_AVE_UIC.pdf
58	84	179	68	Amsterdam - Cologne	2015	https://www.cvs-congres.nl/cvspdfdocs_2015/cvs15_060.pdf
24	82	340	165	Paris - Bordeaux	2017	http://www.traveller.com.au/high-speed-trains-are-now-taking-on-plane-travel-in-asia-and-europe-h0gl70
36	81	492	217	Paris - London	2010	https://www-tandfonline-com.eur.idm.oclc.org/doi/pdf/10.1080/01441647.2013.853707?needAccess=true
23	75	336	164	Rome - Bologna	2009	https://www.vialibre-ffe.com/PDF/4509_AVE_UIC.pdf
78	75		0	New York - Washington DC	2012	https://www.citylab.com/transportation/2014/11/why-more-northeast-us-travelers-take-the-train-than-a-plane-in-2-charts/383158/
98	70	525	159	Amsterdam - Paris	2018	https://zakenreis.nl/artikelen/thalys-groeit-vooral-tussen-amsterdam-en-brussel/
10	69	733	209	Tokyo - Okayama	2016	http://english.jr-central.co.jp/company/ir/annualreport/_pdf/annualreport2016.pdf
41	67	894	223	Tokyo - Hiroshima	2016	http://english.jr-central.co.jp/company/ir/annualreport/_pdf/annualreport2016.pdf
89	66		0	Paris - Stuttgart	2017	http://www.deutschlandfunk.de/zehn-jahre-frankfurt-saarbruecken-paris-ice-und-tgv.1769.de.html?dram:article_id=388695
60	64	553	207	Rome - Milan	2012	https://italospa.italotreno.it/static/upload/com/competition-between-air-and-high-speed-rail.pdf
50	63	621	248	Madrid - Barcelona	2018	https://www.globalrailwayreview.com/news/66620/barcelona-madrid-85-million-passengers/
83	60	746	245	Paris - Marseilles	2014	http://www.cer.be/sites/default/files/publication/The_Economic_Footprint_-_web_-_final_final_30_Sept_0.pdf
12	60		0	Paris - Basel	2011	https://www.nzz.ch/magazin/reisen/zug_oder_flug-1.13568667
33	60			Stockholm - Gothenburg	2017	http://www.railjournal.com/index.php/commuter-rail/mtr-express-takes-on-sj-in-sweden.html
35	60	400	102	Amsterdam - Frankfurt	2015	https://www.cvs-congres.nl/cvspdfdocs_2015/cvs15_060.pdf
88	54		0	Paris - Geneva	2011	https://www.nzz.ch/magazin/reisen/zug_oder_flug-1.13568667
40	54		0	New York - Boston	2012	https://www.citylab.com/transportation/2014/11/why-more-northeast-us-travelers-take-the-train-than-a-plane-in-2-charts/383158/
63	40		0	Stockholm - Malmö		http://www.banekonference.dk/sites/default/files/slides/13/3-1-2_Fast%20trains%20in%20Sweden%20-%20Rail%20Cph%20180514_0.pdf
45	38		0	Paris - Nice	2009	https://www.lignenouvelle-provencecotedazur.fr/files/telechargements/medias/documents/lignenouvelle-synthese-socio-eco-janv13.pdf
57	33	632	148	London - Edinburgh	2017	https://www.globalrailwayreview.com/news/61985/record-passengers-travelling-scotland-london-via-rail-rather-air/
18	31		0	Paris - Frankfurt	2017	http://www.deutschlandfunk.de/zehn-jahre-frankfurt-saarbruecken-paris-ice-und-tgv.1769.de.html?dram:article_id=388694
69	27	644	144	London - Glasgow	2017	https://www.insider.co.uk/news/virgin-trains-takes-record-share-11011037
56	10	1180	199	Tokyo - Fukuoka	2016	http://english.jr-central.co.jp/company/ir/annualreport/_pdf/annualreport2016.pdf

Appendix 7.2: Survey

Survey Rotterdam Airport

Survey nr:

1	Are you travelling to London today? (A) Yes (B) No → **abandon the survey**	
2	What is the purpose of your travel today? (A) Business (B) Leisure (C) Visit Family/Friends (D) Other/Varies	
3	What class do you normally travel? (A) Business (B) Economy (C) Varies	
4	On average, how often do you travel from Rotterdam to London per year? ………. times per year.	
5	Are you aware of the option of travelling by High Speed Train from Rotterdam to London (Eurostar) and/or have you ever taken it? (A) Yes → **Question 6** (B) No → **Question 7**	
6	Did you travel by High Speed Train to London in the past 6 months? (A) Yes → **Question 10** (B) No → **Question 7**	
7	How long do you think the journey takes by train from Rotterdam Central Station to London St. Pancras? ………… hours	

8	At present, the train takes X hours from Rotterdam to London and Y hours back. Now you know this, would you consider taking it in the future instead of the plane? (A) Yes → **Question 10** (B) No → **Question 9** (C) Maybe/Don't know → **Question 9**	
9	In the future, the train will be direct from Rotterdam, taking Z hours. Return will still be Y hours. Would you consider taking the train when this is the case? (A) Yes (B) No (C) Maybe/Don't know → **Continue Question 11**	
10	In the future, the train will be direct from Rotterdam, taking Z hours. Return will still be Y hours. Would you consider taking the train more often when this is the case? (A) Yes, more often (B) No, same (C) Maybe/Don't know	
11	Have you ever travelled by train to other destinations in Western-Europe, for example: Paris, Düsseldorf, Brussels or Frankfurt? (A) Yes (B) No	
12	What is the main reason you chose the plane today? (A) Time (B) Price (C) Frequency (D) Comfort (E) Other: ……………………………………………………….	
13	Are you enrolled in the frequent flyer program of British Airways? (A) Yes (B) No	

14	What is your age? ……………. years	
15	Where do you live? (A) Rotterdam (B) Province of South-Holland (but outside Rotterdam) (C) Somewhere else in the Netherlands (D) London (E) Greater London area (but outside London) (F) Somewhere else in England (G) Elsewhere	
16	Gender of the respondent: (A) Male (B) Female	

X = 4 hours
Y = 3 hours
Z = 3 hours

Appendix 7.3.1: Raw data

Survey nr.	1	2	3	4	5	6	7	8	9	10	11	12
1	A	A	A	A	A	A	A	A	A	A	A	A
2	A	B	B	A	A	A	B	A	A	A	A	A
3	B	B	B	B	B	B	B	B	B	B	C	A
4	5	1	<1	1	1	5	<1	12	2-3	4	4	9
5	A	A	A	B	B	A	A	B	A	A	A	B
6	B	B	B			B	B		Missing	B	A	
7	2	5	3	4	3	1	3	5	5	2		4
8	A	B	C	B	B	A	A	A	B	B		A
9		B	A	B	B				B	B		
10	A					B	B	A			C	A
11	A	B	A	B	A	A	A	A	B	B	A	A
12	A	B	A/B	A	E	A	A	A	A	D	E	A
13	B	A	B	B	A	A	B	A	A	A	A	A
14	52	25	62	26	46	27	31	50	51	35	41	29
15	B	B	F	D	D	A	G	F	C	C	D	D
16	A	A	B	A	A	A	B	B	A	B	A	B
Note Q12:					Convenience						Convenience	

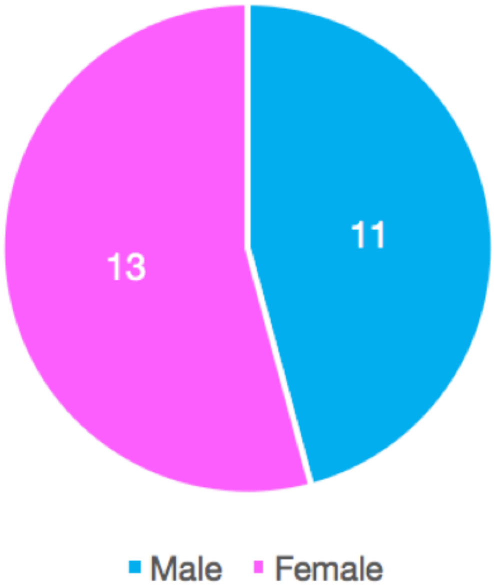
Survey nr.	13	14	15	16	17	18	19	20	21	22	23	24
1	A	A	A	A	A	A	A	A	A	A	A	A
2	B	A	B	A	A	B	C	A	C	A	B	A
3	B	B	B	B	B	B	B	B	B	B	B	B
4	1-2	12	10	<1	1	1	<1	2-3	10	6	<1	<1
5	A	B	A	A	A	A	A	A	A	A	A	B
6	B		B	B	B	B	B	B	A	A	B	B
7	6-8	2	02:50	3	3	3	3-4	2			3	2,5
8	C	B	A	A	A	A	B	A			A	A
9	A	A					A					
10			A	A	A	B		A	A	A	C	A
11	B	A	B	A	A	B	B	A	B	A	A	A
12	E	E	A	B	A	B	E	A	A	B/A	B	B
13	A	A	B	B	B	A	B	A	A	B	B	A
14	41	33	40	37	33	25	75	46	60	34	23	34
15	C	D	B	B	G	D	B	F	A	A	A	D
16	A	A	B	B	B	B	B	A	B	B	B	A
Note Q12:	Did not book myself	only option					Makkelijk (convenience)					

Appendix 7.3.2: Treated data

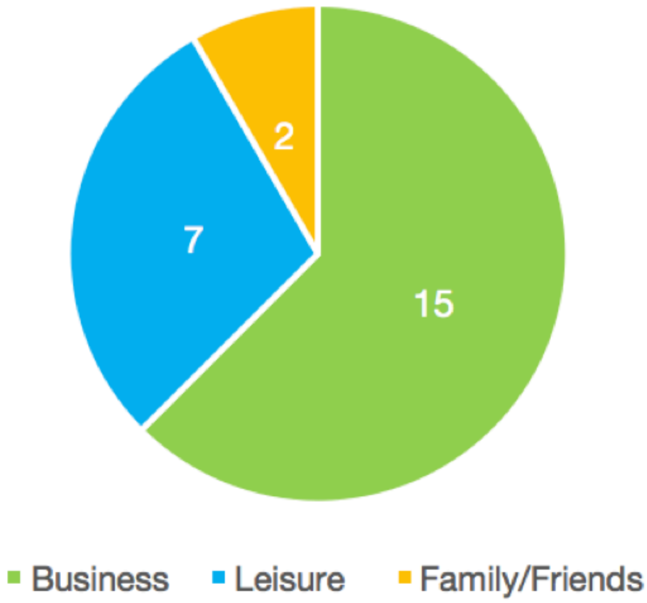
Survey nr.	1	2	3	4	5	6	7	8	9	10	11	12
1	A	A	A	A	A	A	A	A	A	A	A	A
2	A	B	B	A	A	A	B	A	A	A	A	A
3	B	B	B	B	B	B	B	B	B	B	C	A
4	4-6	1-3	0-1	1-3	1-3	4-6	0-1	10+	1-3	4-6	4-6	7-9
5	A	A	A	B	B	A	A	B	A	A	A	B
6	B	B	B			B	B		Missing	B	A	
7	<3	>4	3-4	3-4	3-4	<3	3-4	>4	>4	<3		3-4
8	A	B	C	B	B	A	A	A	B	B		A
9		B	A	B	B				B	B		
10	A					B	B	A			C	A
11	A	B	A	B	A	A	A	A	B	B	A	A
12	A	B	A/B	A	Convenience	A	A	A	A	D	Convenience	A
13	B	A	B	B	A	A	B	A	A	A	A	A
14	50-59	20-29	60-69	20-29	40-49	20-29	30-39	50-59	50-59	30-39	40-49	20-29
15	B	B	F	D	D	A	G	F	C	C	D	D
16	A	A	B	A	A	A	B	B	A	B	A	B

Survey nr.	13	14	15	16	17	18	19	20	21	22	23	24
1	A	A	A	A	A	A	A	A	A	A	A	A
2	B	A	B	A	A	B	C	A	C	A	B	A
3	B	B	B	B	B	B	B	B	B	B	B	B
4	1-3	10+	10+	0-1	1-3	1-3	0-1	1-3	10+	4-6	0-1	0-1
5	A	B	A	A	A	A	A	A	A	A	A	B
6	B		B	B	B	B	B	B	A	A	B	B
7	>4	<3	<3	3-4	3-4	3-4	3-4	<3			3-4	<3
8	C	B	A	A	A	A	B	A			A	A
9	A	A					A					
10			A	A	A	B		A	A	A	C	A
11	B	A	B	A	A	B	B	A	B	A	A	A
12	Other	Other	A	B	A	B	Convenience	A	A	A/B	B	B
13	A	A	B	B	B	A	B	A	A	B	B	A
14	40-49	30-39	40-49	30-39	30-39	20-29	70+	40-49	60-69	30-39	20-29	30-39
15	C	D	B	B	G	D	B	F	A	A	A	D
16	A	A	B	B	B	B	B	A	B	B	B	A

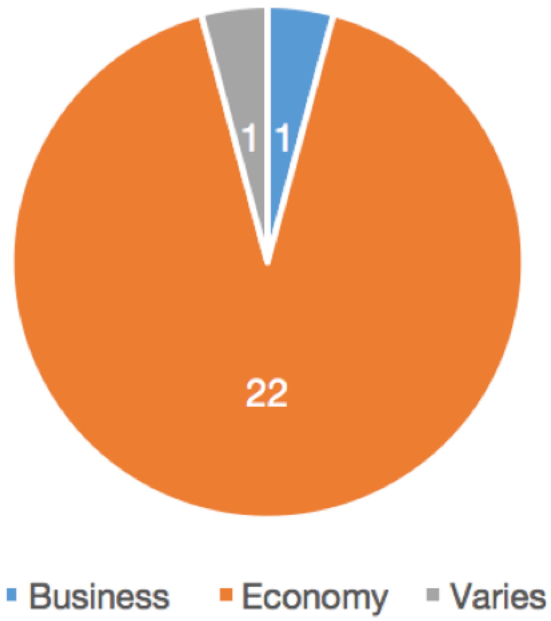
Appendix 7.4: Characteristics of the sample



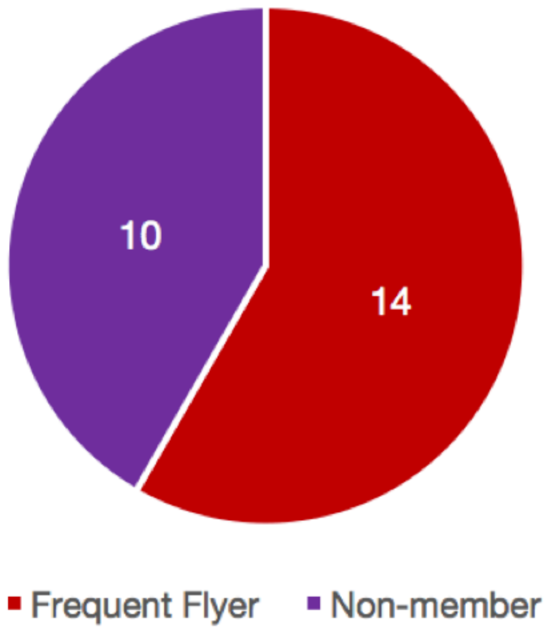
7.4.1: Gender of the respondents



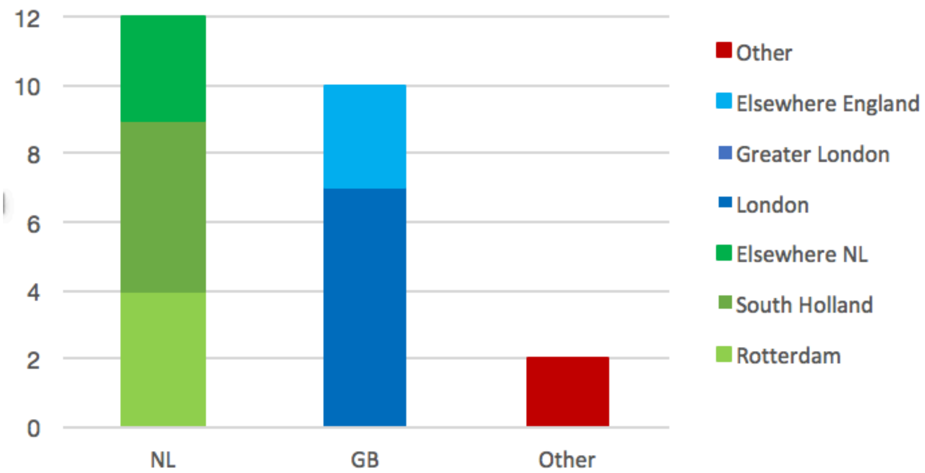
7.4.2: Purpose of travel



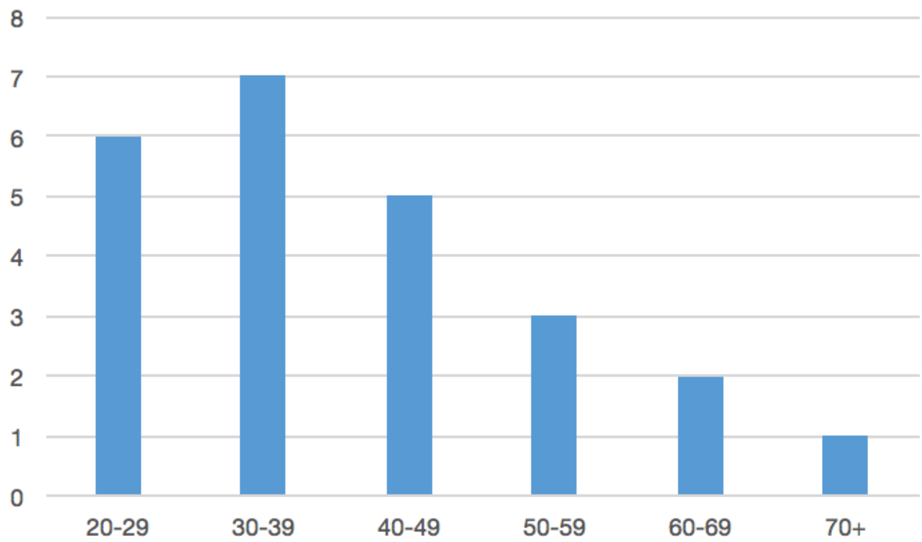
7.4.3: Class of travel



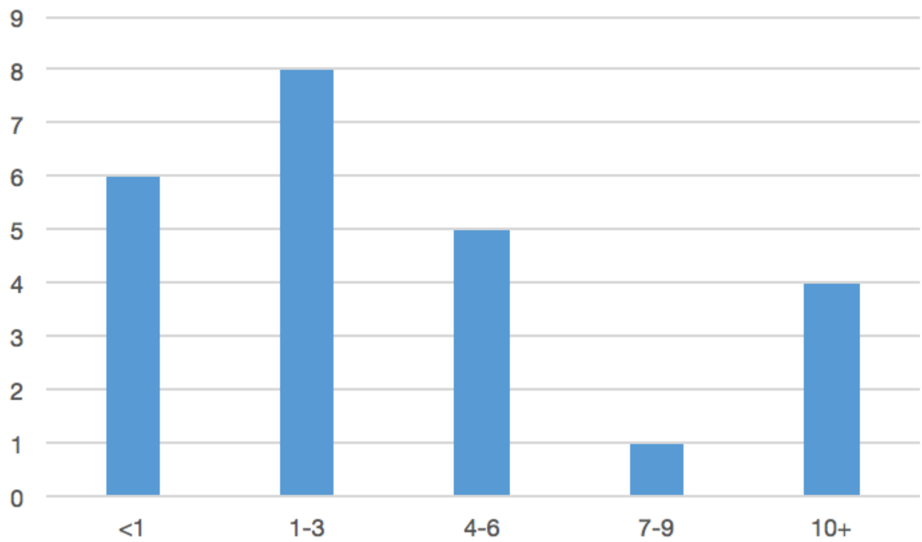
7.4.4: Number of frequent flyers



7.4.5: Place of residence of respondents



7.4.6: Age of the respondents



7.4.7: Frequency of travel

Appendix 7.5.1: relationship between frequency of travel and the importance of the factor time (low frequency is 0-1)

Frequency 0-1		Frequency 0-1		p-value
Number	***Time most important***	***Number***	***Time most important***	
6	1	18	10	0,075

Appendix 7.5.2: relationship between frequency of travel and the importance of the factor time (low frequency is <4)

Frequency <4		Frequency >3		p-value
Number	***Time most important***	***Number***	***Time most important***	
14	5	10	6	0,119

Appendix 7.6: the importance of the factor time for frequent-flyers and non-members of BA's frequent-flyer program.

Frequent- flyer	**Number**	**Time most important**	**Percentage**
yes	14	6	43%
no	10	5	50%