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High-speed rail and office location choices. A stated choice experiment for the Netherlands

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A R T I C L E I N F O

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A B S T R A C T

High-speed rail is seen as a factor contributing to the attractiveness of a location for economic activities. This paper focuses on how the level-of-service characteristics of railway stations, and in particular the presence of high-speed train services, influence the attractiveness of locations for specific types of offices. The results are presented for a stated choice experiment for location choices of offices in the Netherlands. It is concluded that the availability of high-speed train services contributes to the attractiveness of a location for offices. For internationally-oriented offices the areas around stations with international high-speed train services are attractive because of their good international accessibility. We also found an indication that high-speed train services can raise the status of an office site. In the Netherlands, the domestic high-speed train services are less relevant for location choices, because of the small domestic distances. Besides high-speed train services, other location characteristics that determine how well a site is connected to the railway network are also found to be important for location choices. Thereby differences between offices occur, which can partly be explained by the number of trips to/from an office.

1. Introduction

The European high-speed railway (HSR) network is expanding to become an extensive network interconnecting the major Western-European agglomerations. Also in the Netherlands new HSR lines are being developed for both domestic and international passenger transport. This has resulted in an increased interest in the appraisal of new railway infrastructure. Thereby special attention is given to the indirect effects of the infrastructure, particularly spatial-economic effects. Several studies (e.g. Sands, 1993) suggest that a large part of the high-speed train's spatial-economic effect takes place at a regional scale, due to the relocation of economic activities already present in the region. This strengthens the case for studying the location of firms and institutions at this spatial scale.

However, empirical researches that study the impact of railway infrastructure on the location choices of firms and institutions at a regional level often deal with the railway infrastructure in a rather crude way, by only considering the presence of a railway station within a certain proximity. We argue that not only the presence of a railway station but also the 'level-of-service' provided by the station is of importance. The term 'level-of-service' comprises many aspects of the train services, such as the frequency and type of services. Furthermore, most quantitative empirical research gives little detail about the characteristics of the firms and institutions. Typically segmentation takes place on the basis of the branch of industry. However, other characteristics might be just as important for decision-makers rating the different facets of a location's accessibility. For example, a firm or institution's spatial orientation (the spatial extent of its target market) and the number of visits made to and from the location may also be important factors.

The current paper focuses on whether and how the level-of-service of railway stations, and in particular the presence of high-speed train (HST) services, has an effect on the office location preferences of firms and institutions. The paper addresses this question by presenting the results of a stated choice experiment that includes respondent heterogeneity and interaction effects. An innovative element thereby is that we include both commuting and business trips. As a result, it was possible to study how these trip motives related to the importance of accessibility for an office's location choice.

The study area of the research is the highly urbanized Randstad region in the Netherlands (see Fig. 1). It was only in September 2009 that the first domestic HST services in the Netherlands using HSR track came into use, and even that service uses some conventional track. At the time of doing the empirical research for this paper, the HSR services used only conventional track. At this point these services were still rather infrequent and did not yet significantly improve travel times within the Netherlands. Therefore the study has the character of an ex ante research. Current HST

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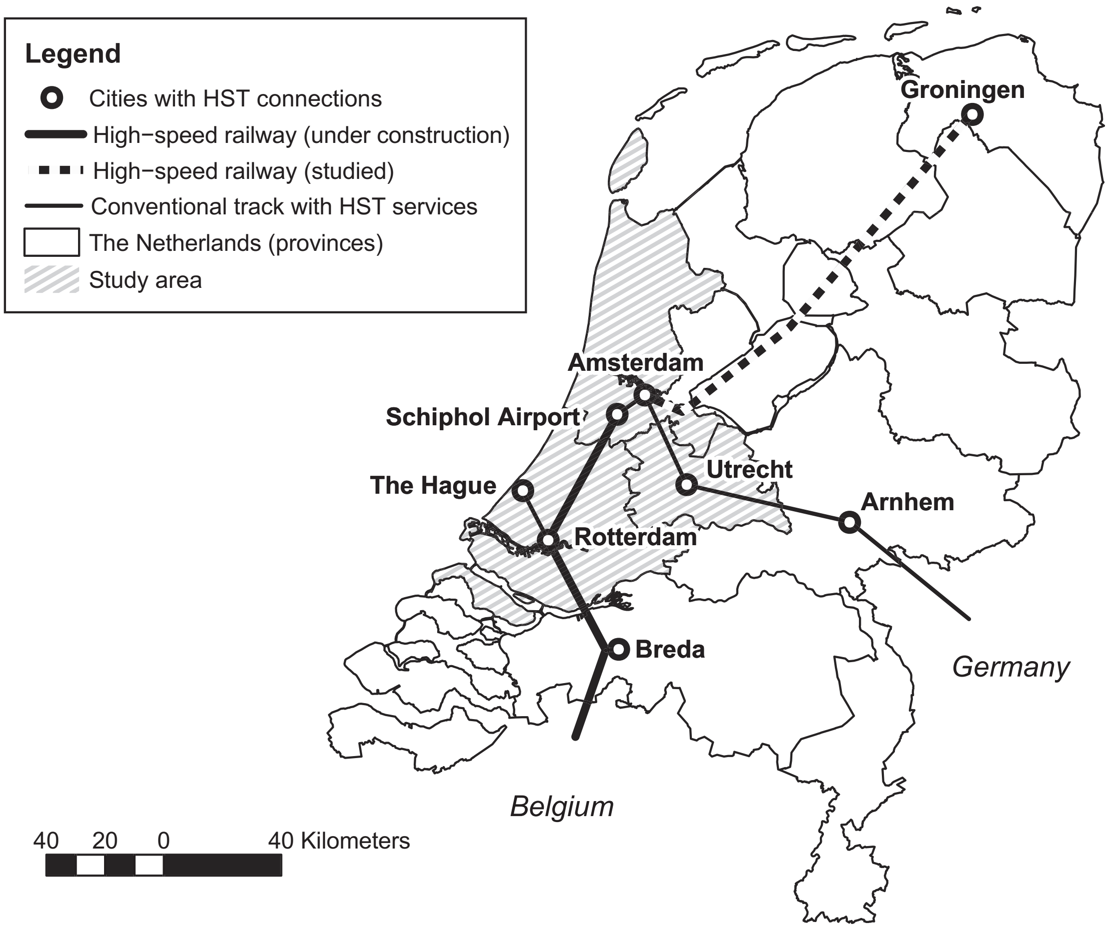

Fig. 1. Location study area within the Netherlands and HSR-lines.

connections in the Netherlands are the Amsterdam–Rotterdam–Brussels–Paris service and the Amsterdam–Arnhem–Cologne–Frankfurt service. For the first service new high-speed infrastructure has been built. Furthermore a new HSR line between Amsterdam and Groningen in the North of the Netherlands has been under discussion for more than a decade, but the current policy is to not construct it.

The rest of this paper is organised as follows. The next section describes how (high-speed) railways can influence the spatial configuration of economic activities, with an emphasis on the regional scale. Section 3 describes the stated choice experiment. The results of the stated choice model are then presented in Section 4. In this Section we discuss how the implementation of HSR in the Netherlands might influence the attractiveness of locations for different types of offices. Finally, Section 5 sets out some concluding remarks.

2. High-speed rail, accessibility and spatial-economic development

In order to understand how changes in the transport system can impact on the spatial configuration of economic activities the concept of accessibility is important: accessibility can influence the location of economic activities. This section discusses the literature focusing on the relevance of HSR accessibility for location choices.

2.1. Accessibility impact on the location of economic activities

Transport infrastructure can influence the location of economic activities because of its impact on the accessibility of locations. A location's accessibility is thereby seen as the ease with which other relevant locations can be reached from this location (and vice versa) via the transport system. A high level of accessibility makes a location more attractive for offices. In the context of location choices, two different forms of accessibility are relevant: centrality and connectivity.

Centrality is concerned with how a potential location is situated within a transport network relative to possible origins and destinations. Usually, an impedance function is applied, making origins and destinations further away weigh less than those near by. Several authors have analysed the impact of HSR in Europe using centrality indicators, including Bruinsma and Rietveld (1993), Spiekermann and Wegener (1996), Gutiérrez et al. (1996) and Gutiérrez (2001). In general, these studies show differences in accessibility *between* regions rather than *within* regions. Where impedance functions are used, steeper impedance functions generally lead to more variation on a lower spatial scale.

The connectivity of a location, on the other hand, relates to how well this location is connected to a certain transport network. Connectivity is normally based on transport nodes, such as a railway station, an airport or a motorway access ramp. A distinction can be made between access (mainly: distance, travel time) to the nearest transport node only versus the quality of this transport node, the latter being the level-of-service in the case of a railway station. Compared to the centrality indicators, connectivity indicators show more variation at smaller spatial scales. Therefore these indicators are better suited to studying the differences in location attractiveness within a region, whereas centrality indicators give more information on the economic potential of a region as a whole. For HSR the presence or absence of a station with HST services is especially used in studies on the Japanese Shinkansen; Brotchie (1991) mentioned studies by Hirota (1984) and Nakamura and Ueda (1989) who statistically compared the economic activities in cities and regions both with and without a Shinkansen station. These studies found significant correlations between the presence of Shinkansen stations and employment growth in several sectors, growth in per capita income and the increase of commercial land values. For Europe, case studies on specific regions with an HST connection, which in particular have been carried out on the French TGV (e.g. Bonnafous, 1987; Sands, 1993), show the urban and regional impact of HSR. We discuss the results of these studies below.

2.2. Spatial-economic effects of high-speed rail

An important subject in research on HSR is which cities and regions benefit most from an HST connection. Most studies show that the past and current European HSR developments have had a centralizing effect on economic activities, both on a regional or urban scale as well as on a larger spatial scale. For the European region as a whole both Spiekermann and Wegener (1996) – using the number of persons who can be reached within five hours travel by rail – and Gutiérrez et al. (1996) – who calculated the average travel times to all locations in the European Union weighted by gross domestic product – showed HSR accessibility to be highest in the central regions and cities.

On a national scale, for France, Plassard (1991) also observes that HSR has a centralizing effect. The star-shaped TGV network facilitates the ongoing tendency of economic activities to be concentrated at a limited number of locations, with Paris being the centre of this network. However, Gutiérrez (2001) shows that the effect of HSR can differ depending on the spatial scale of the analysis: in Spain, the HSR line Madrid–Barcelona–France decreases the variation of accessibility on a European scale (since the peripheral Iberian peninsula is better connected to the rest of Europe) but increases accessibility differences on a national scale (within Spain the larger agglomerations benefit most from the infrastructure).

At a regional level the effect of HSR is concentrated in the immediate vicinity of the stations (Plassard, 1991; Vickerman, 1997). Compared to conventional rail, for HSR there is hardly any corridor effect. A number of studies have examined the effect of specific HST connections on the location of economic activities at a regional or urban level; this mainly concerns case studies in France. Amongst others, Haynes (1997) and Rietveld et al. (2001) provide extensive overviews of these studies. In these case studies both the effects of centrality on the attractiveness of regions and connectivity on the attractiveness of places within regions can be examined. The improved centrality of a region can make a city in this region a more attractive location for offices compared to main cities in other regions. For example, in a case study of Nantes, Sands (1993) observed a number of relocations from Paris to Nantes after Nantes received its TGV connection. On the other hand, the improved interregional connectivity of a city served by an HST increases its attractiveness for offices relative to other locations in the same region. This centralizing effect was observed for the regions around both Lyon (Bonnafous, 1987) and Nantes (Sands, 1993). Additionally, examining statistical studies on the Japanese Shinkansen, Haynes (1997) concludes that the dominant effect is the dispersion of growth from pre-train centres to the new Shinkansen stations. As a general conclusion for France (Haynes, 1997), however, the TGV was of minor importance for the location decisions of most firms. Firms in the manufacturing industries in particular are constrained in their location choice by other factors.

Although these studies provide useful insights into potential HSR effects they are of limited use for determining the spatial-economic effects in a specific case, such as for the Netherlands. Firstly, from these researches it is difficult to assess what part of the observed developments can be ascribed to the presence of HST services, because location choices are based on a large number of location factors. Market access, the availability of qualified staff and the availability of office space are among the location factors that are often highly ranked in studies of location choices (e.g. Healey and Baker, 1996). Many of these location factors are, however, directly or indirectly related to accessibility, asserting the need for more complex analyses. A second reason for the limited transferability of results for specific Dutch cases is the difference between the Netherlands and other European countries with HST services, like France and Germany, due to the much smaller size of the country. Because HSR is most competitive in travel time for distances of 200–600 km (Vickerman, 1997), in the Netherlands HSR is mostly seen as an international transport mode. As a result, the possible occurrence of border effects should be taken into account (e.g. Nijkamp et al., 1990): barriers such as legal barriers or language barriers may lower the probability that an office has cross-border business contacts. These effects can influence the distribution of trips over space, leading to relatively few trips by HST and thus an HSR station and the related services will have a smaller impact on location choices.

3. Design of a stated choice experiment for office locations

To study the effects of HSR in the Netherlands on office location decisions a stated choice experiment was carried out for the decision-makers in offices. The purpose of the experiment was to gain insight into the location preferences of offices that are located within the Randstad region and to study how important HSR is for the attractiveness of a location. It does not give information about the extent to which the total number of offices or jobs in the Randstad region might change as a result of the HSR. Also, no account is taken of feedback mechanisms that might occur. Possible feedback mechanisms include higher prices for real estate due to the increased attractiveness of a location near an HST station, and a decrease in car accessibility because a higher urban density can lead to an increase in traffic jams.

3.1. Methodology

The empirical research is based on a discrete choice framework. A random parameter logit (RPL) model (a version of the mixed logit class of models, see Hensher and Greene, 2003; Train, 2002) is used to model location choices. The RPL model calculates the probability that an individual chooses an option i out of a choice set J using a simple logit equation[1]

$$P(i|J) = \exp(V_{iq}) \Big/ \sum_j \exp(V_{jq}) \tag{1}$$

Similar to the well-known multinomial logit (MNL) model, in the RPL model the observed utility component V_{iq} is a function of a set of K option-specific attributes X_{ik}. Contrary to the MNL model, however, in an RPL model the taste parameter b_{kq} is dependent on a random parameter which, in most applications, has a normal or uniform distribution. This random parameter takes account of unobserved preference heterogeneity, in addition to observed heterogeneity represented by a set of M heterogeneity characteristics W_{mq}. These observed characteristics are quantified in the form of 0/1 dummy variables (specified in Table 2 in the next section). In

[1] We used the software package NLogit version 3.0.3 (Econometric Software, 2003) for model estimation.

the current research this allows us to study how the attractiveness of locations differs amongst offices. The resulting observed utility function is

$$V_{iq} = \sum_K b_{kq} X_{ik} = \sum_K \left(\left[\beta_{k,0} + \sum_M \beta_{k,m} W_{mq} + \sigma_k v_{k,q} \right] X_{ik} \right) \quad (2)$$

where the random parameters are divided into a fixed component σ_k that equals the standard deviation of the random parameter, and an individual specific random component $v_{k,q}$ with a standard deviation of one. We used uniform distributions for effect-coded variables and normal distributions for other attributes. An advantage of the RPL model over the MNL model is that it takes account of multiple observations per respondent, which is common with stated choice experiments. Note that the unconstrained normal distribution can result in counterintuitive coefficient values for part of the cases, e.g. for station access time. The influence of this is not large if the standard deviations are small compared to the mean effect.

In the stated choice experiment respondents are asked to choose an option from a set of hypothetical choice alternatives (see e.g. Louviere et al., 2000, for more background on stated choice experiments). As opposed to revealed choice data, stated choice experiments are capable of dealing with choice options not present in the current situation, such as new HSR services using dedicated infrastructure in the Netherlands. Furthermore, stated choice data have the advantage that attributes can be designed to be uncorrelated over the observations; therefore it is possible to better estimate the contribution of attributes separately, which is often not possible in revealed choice models. A final advantage is that multiple observations can be acquired from a single respondent, resulting in a more extensive data set with little effort. The use of stated choice data also has some disadvantages. The main disadvantage is that respondents might behave differently in the survey than they would do in reality; this can occur both unintentionally or on purpose, to give a certain message. Nevertheless stated choice experiments are nowadays commonly used in several research fields, including transport studies. Stated preference techniques are also increasingly applied in research on location choices (recent examples are e.g. Leitham et al., 2000; Earnhart, 2002). Still, stated choice experiments are only used to a limited extent in studies on the impact of transport infrastructure on the location of economic activities (Rietveld, 1994; Leitham et al., 2000), especially in the case of offices.

3.2. Survey design

The design of the experiment was based on a series of in-depth interviews with respondents from the target group who had made a location choice within the five years previous to the interview. The interviews yielded a preselection of attributes that were probably significant. They also gave ideas for possible hypotheses that could be tested with the experiment.

The relevance of nine attributes was studied in the experiment. This included attributes related to accessibility by train, attributes representing accessibility by car, as well as attributes having no direct relationship with accessibility (although indirect relationships might be possible). The accessibility indicators taken into account are all connectivity indicators. Centrality indicators are more difficult to interpret by the respondents and are therefore less suitable to embed in a stated choice experiment.

Table 1 shows the attributes and their values. By varying between four levels (see Table 1): for the station access time and the frequency of trains between four levels, it is possible to estimate non-linear effects.

It might be too complicated for respondents to consider nine attributes in a single choice situation. For example Green and Srinivasan (1990) recommend a maximum of six attributes per choice situation. (However, Hensher, 2006, argues that complexity is part of the natural process of decision-making.) To reduce complexity, a so-called bridging design is used, where the design of nine attributes is split into two designs of six attributes each, thus having three attributes in common. Respondents were instructed to consider the attributes not explicitly mentioned for the choice alternatives to be equal across the alternatives and at an acceptable level. The exclusion of attributes from the sub-designs potentially leads to responses being biased and might result in error variance between the subsets. These are the drawbacks of this approach, but a test with an estimated model did not indicate that a significant error variance existed in this application's data. Table 1 denotes for each of the attributes the level between which they vary and the sub-design in which they occur.

For each of the two designs the attributes were arranged into choice alternatives according to an orthogonal fractional factorial design. Contrary to a full factorial design in a fractional factorial design not all combinations of attribute levels are included. Therefore fewer observations are needed for the model. Note that more recently new design approaches (efficient designs) have been developed that are more suitable for small sample sizes, see e.g. Bliemer and Rose (2005). By basing the design on pilot data these designs can effectively yield more reliable parameter estimations.

With a fractional factorial design a predefined set of interaction effects can only be estimated in the discrete choice model. The estimation of interaction effects shows whether and how the presence of an attribute influences the evaluation of other attributes. Interaction effects can be estimated for combinations of two or more attributes, but in practice estimation is limited to two-way and three-way interaction (Louviere, 1988). With a bridging design interaction effects can only be estimated if both attributes are present within the same sub-design. Furthermore, estimating

Table 1
Attributes and levels in the stated choice experiment.

Attributes	Levels	Sub-design
Accessibility by train		
Travel time to a station	5, 10, 15 or 20 min	Both
Transport mode to this station	Walk or bus	1
Total frequency of trains departing from this station	4, 16, 28 or 40 trains per hour	Both
Type of train services departing from this station	Only regional trains, also intercity trains, also domestic HST, also international HST	Both
Accessibility by car		
Travel time to a motorway access	5 or 15 min	1
Number of parking places per 100 employees	75 or 100	2
Non-accessibility factors		
Type of building	"Nice but not extraordinary" or "architecturally remarkable"	2
Type of environment	"In a city centre" or "in a city-rim office park"	1
Price of real estate	€150 or €200 per m^2 per year	2

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interaction effects requires that the fractional factorial design be taken into account, such that little or no correlation exists between the attributes of interest. In the current model there is the possibility of estimating some relevant two-way interaction effects:

1. Complementarity of train-related accessibility factors: attributes expressing accessibility by train might have a mutual reinforcing effect. A special case is the non-linear interaction between station access time and station access mode.
2. Substitution of train- and car-related accessibility factors: a high level of car accessibility might reduce the need for a high level of train accessibility and vice versa.
3. HSR accessibility and an image effect: HST services raising the image of a location (the so-called image effect): a location with good accessibility, for example near an HSR station, might have a high status and therefore attract offices even when these do not actually make use of HST services on a regular basis (see also Sands, 1993). To study this hypothesis we tested for an interaction between the availability of HST services and the type of office building: an architecturally outstanding building and a prestigious environment might strengthen each other.

For each sub-design an orthogonal fraction consisting of 32 binary choice scenarios was constructed. Fig. 2 gives an example of a choice situation as evaluated by the respondents.

The respondents were sent one out of eight versions of the questionnaire. Each questionnaire contained eight choice scenarios (four out of each sub-design). Choice situations of the two sub-designs were to be assessed alternately, as a way of avoiding patterned responses. Only returned questionnaires with all eight choices completed were analysed.

Potential respondents were obtained from a sample from the LISA database, which contains address data of practically all business and government establishments in the Netherlands ordered by branch of industry, number of employees and geographical location. Establishments from the study area (the provinces of North Holland, South Holland and Utrecht) were selected that have at least 20 employees. Stratification was applied with respect to the number of employees (from 20 up to 100 employees; more than 100 employees) and the branch of industry (business and financial services; other industries) to form four different strata. Stratifying on the number of employees reduces an overrepresentation of smaller establishments when studying the location of employment. The branch of industry was used as a stratification factor to ensure sufficient diversity among the offices.

In September–October 2003 potential respondents were contacted by telephone. As the database used does not make a distinction between offices and other establishments, it was first verified that the establishment was an office. Subsequently, an appropriate respondent within the office was found, preferably a member of the management who, because of his/her function, was (jointly) responsible for or otherwise closely involved in (actual or potential future) location decisions. From a telephone interview several heterogeneity characteristics of the respondents were obtained. If the respondent accepted, a stated choice form was sent. The form was sent by post or e-mail, depending on the respondent's preference.

Although the data were collected several years ago, they are still regarded as relevant to the current situation. There are no indications that office decision-makers might have changed their view on railway accessibility.

3.3. Data analysis methodology

To estimate an RPL model the (linear and non-linear) attributes are coded as orthogonal codes (see Louviere, 1988), thereby retaining the original unit scale. For the station access time attribute quadratic and cubic polynomial codes are used to determine non-linear effects. Together with the linear effect these quadratic and cubic codes make up a third-order polynomial function. The appraisal of additional station access time is expected to be less negative when access time increases and is also expected to depend on the distance that is maximally acceptable to walk; these aspects can be clarified by examining the polynomial representation. For the train frequency at a station non-linear effects are accounted for by testing the natural logarithm of the frequency apart from the linear effect. Non-linear effects are expected to be relevant because an increase in train frequency may be very beneficial for stations with a poor frequency but might add less value for stations that already had a high frequency. The type of train services attribute is represented by effect codes instead of orthogonal codes. Interaction effects are constructed by multiplication of the relevant orthogonal and/or effect codes. By using orthogonal codes and effect codes the correlations among the attributes and their interaction effects are minimized.

Several indicators for observed preference heterogeneity, including office characteristics related to commuting and business travel, were derived from the information collected through the telephone interviews to represent the office characteristics. The characteristics can be used to determine how the importance of accessibility relates to the frequency and properties of trips (most notably trip purpose – commuting versus business travel – and the spatial dispersion of origins/destinations). To the best of our knowledge no research exists that studies these characteristics in

Suppose your company or branch office needs to relocate and you could only choose between the following two locations, which are identical for all characteristics that are not explicitly mentioned:

	Location **A**	Location **B**
Type of environment	In a city-rim office park	In a city centre
Proximity of a railway station	15 minutes walk	5 minutes walk
Frequency of trains at this station (in total)	46 trains per hour	32 trains per hour
Type of train services from this station	Commuter and intercity trains	Commuter and intercity trains, domestic and international HST
Proximity of a motorway exit	15 minutes car drive	5 minutes car drive

Which of these locations would you choose?

Fig. 2. Example of a choice situation.

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relation to location choices. The following heterogeneity indicators were used in the final model (these appeared to perform best and provided significant results):

3.3.1. The branch of industry

For the branch of industry a distinction was made between the business and financial services industries and other industries, consistent with the stratification applied by the data collection. The branch of industry is used for segmentation in most research on firm locations. In the current research the relevance of the branch of industry for both accessibility and non-accessibility attributes was tested.

3.3.2. Visiting customers

The accessibility of an office is assumed to be more important if it is visited by a large number of customers. The number of customers visiting an office location is represented by the percentage of employees receiving customers at the office at least once a month. We included a dummy variable if the share exceeds 50%.

3.3.3. Employees visiting customers

If many employees visit customers it is assumed that accessibility is relatively important for an office. However, it is possible that a reverse effect may occur for accessibility by train: if employers give employees who visit customers frequently a company car, accessibility by train may become less important. The number of employees visiting customers is represented by the percentage of employees visiting customers away from the office at least once a week. Again we included a dummy if the share exceeds 50%.

3.3.4. International business trips

If employees frequently make international business trips the importance of international accessibility may be relatively high. Business trips to Belgium, Germany and France are particularly relevant for HSTs, as they have direct HST connections with the Netherlands. We included a dummy variable if offices have employees making international business trips at least once a month, on condition that their destinations include at least one of the aforementioned countries.

Apart from the main effects and the non-linear interaction between station access mode and station access time, in the final model only linear interaction effects and heterogeneity effects with a significance level of at least 80% were included. No further non-linear interactions or preference heterogeneities were tested because of the size of the data set that is available.

In order to better reflect the spatial distribution of overall employment rather than the characteristics of the offices in our study, the observations were weighted based on the offices' number of employees. However, to retain the orthogonal properties of the survey design the weight of the eight versions of the questionnaire was set to be equal within each segment. Thus, the weighing was applied within each segment/version combination and between distinct segments (based on the average size of the offices in the segment).

4. Results

This section describes the results of the RPL model. Firstly, the respondent characteristics and parameter estimates are given. Subsequently the results for the different types of accessibility and non-accessibility indicators are discussed.

4.1. Respondent characteristics

In the stated choice experiment, 167 valid responses (i.e. forms with all eight choices completed) were received, which is about 1.9–2.3% of the target population.[2] The total number of forms sent was 296, leading to a response rate of 56%. The variation in the respondent characteristics are shown in Table 2. The dummy variables that represent heterogeneity among respondents (W_{mq}) show low mutual correlations, resulting in r^2 values of 0.30 or lower between heterogeneity attributes in the final model.

From the percentages of office characteristics in Table 2 an indication can be derived as to what extent a possible selective response has occurred for the stated choice questionnaire. Although the choice questions are formulated in a general way, the response might be lower for office categories that feel indifferent about some of the attributes and higher for office categories that identify more with some of the attributes. Comparison of the category percentages for the stated choice questionnaire in Table 2 with the corresponding percentages from the initial telephone interviews shows that a possible selective response can be assumed to be small. The largest difference exists for employees making international business trips. From the telephone interviews 33.9% of the offices have employees who regularly make international business trips to destinations that include Belgium, Germany and/or France; from the stated choice questionnaire, however, the percentage was 38.3%. Furthermore, offices that regularly receive customer visits are overrepresented; 29.3% of the respondents have 50% or more employees receiving customer visits at least once a month compared to 26.1% from the telephone interviews. Differences in the other office characteristics are considerably smaller. The occurrence of a selective response is not expected to have serious consequences for the model results, since it is corrected for by estimating different parameter values on the basis of the office characteristics.

4.2. Respondent's previous location choices

In the telephone interviews we collected qualitative information on previous location choices by asking respondents who had relocated in the five years before the interview additional questions. The response to these questions was limited, but provided useful background information into the reasoning of the respondents.

A first question was the primary reason for their relocation and yielded a useful response from 98 respondents. The dominant motive for relocation (52 respondents) was lack of space at the previous location. Only eight respondents mentioned issues relating to accessibility. Accessibility is thus not often an incentive for relocation.

When asked about the predominant factor for choosing their current location, accessibility-related factors were mentioned much more often: by 44 out of 68 respondents. Responses included phrases such as "centrally located within the country", "close to a station" or broader "good accessibility". These responses suggest that accessibility can be an important factor for office location choices.

4.3. Parameter estimation results

The results of the logit model estimations are shown in Table 3. The main effects account for the larger part of the model's goodness-of-fit; a model with only the main effect parameters has a

[2] The size of the target population of offices with at least 20 employees is not exactly known but is derived from the selection by the telephone interviews.

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Table 2
Respondent characteristics to represent preference heterogeneity.

Office characteristics	Levels	Value[a]	Sample (%)
Branch of industry	Business/financial services	1	60.5
	Other	0	39.5
Employees receiving customers at least once a month	Less than 50% of employees	0	60.5
	50% or more	1	29.3
	Unknown	0	10.2
Employees visiting customers at least once a week	Less than 50% of employees	0	58.7
	50% or more	1	34.1
	Unknown	0	7.2
Destinations of employees making international business trips at least once a month	Include HST area[b]	1	38.3
	Exclude HST area	0	7.2
	Not relevant/unknown	0	54.5

[a] The 0/1 dummy variables are the W_{mq} in Eq. (2).
[b] Destination countries include at least one of the countries with a direct HST connection from the Netherlands: Belgium, Germany and France.

ρ^2 of 0.259. Two interaction effects are included in the model. The interaction effects contribute little to the goodness-of-fit – a model with both main effects and interaction effects has a ρ^2 of 0.261 – but are important as they give information relevant to the scope of the research. A test with error coefficients did not show a significant error variance between the two subsets of the bridging design. The two subsets were therefore merged without estimating error coefficients.

A number of heterogeneity effects are significant. The relevant heterogeneity parameters concern the branch of industry and the trip frequency as well as the spatial orientation of the office. For the type of train services the heterogeneity parameters are restricted to keep them equal for different train services, because not enough data is available to estimate the model with the heterogeneity parameters for all the types of train services treated separately.

The RPL model has a higher goodness-of-fit than an MNL model (the latter having a ρ^2 of 0.300 but this is not discussed here in more detail). Several random parameters are significant. The occurrence of random parameters with a larger effect than the fixed effects heterogeneity parameters indicates that the office characteristics used have only a limited capability for explaining taste differences, even though their influence is statistically significant. Several heterogeneity indicators that are significant in the MNL model are not significant in the RPL model. This is particularly the case for characteristics referring to the spatial dispersion of the office's employees and customers. These heterogeneities appear to fall well within the standard deviation of the respective random parameter. In these cases a more continuous random distribution represents the diversity of offices better than the discrete categorisation by dummy variables, where the heterogeneity within each category is not taken into account.

4.4. Station access

The station access time has, as expected, on average a significant negative influence on the attractiveness of a site. Furthermore, being situated within walking distance of a station adds extra value to the location. Because station access time and access mode are closely connected in the formulation of the choice alternatives, the interaction effect of these attributes is estimated in the model. The utility coefficients of this interaction are not significant, although Fig. 3 demonstrates the relevance of the interaction effect: the polynomial function for the station access time by bus shows a different shape than for station access time on foot.

Fig. 3 supports the hypothesis that the utility effect of the station access time is non-linear for access by foot and that there appears to be a threshold distance of 10–15 min walking time. This threshold also corresponds to the respondent's perception of being located within walking distance, as was asked during the telephone interviews: 74% of the respondents who proclaim to be located within walking distance estimate their walking time to the station to be 10 min or less. Locations with a walking time below this threshold can be seen as being within an acceptable walking distance; within this range the walking time does not significantly influence the utility of the location. On the other hand, for walking times above the threshold distance station access is considered to be poor, the differences in walking time are less important and other transport modes are more likely to be chosen. There is no such threshold distance present for station access by bus, instead the utility effect of the station access time by bus seems to decrease more gradually as access time increases.

If the access time is equal, walking is preferable to taking the bus, as shown in Fig. 3. This preference is less extensive (but still statistically significant) for offices in the business and financial service industries compared to offices in other industries (the heterogeneity effect is omitted in Fig. 3). No heterogeneity effects were tested for station access time, as was discussed in Section 3.

4.5. Station level-of-service

We studied the level-of-service of a station, focusing on train frequency and the type of train services (regional, intercity, HST). For train frequency the natural logarithm appeared to perform significantly better than the linear effect. This suggests that, as expected, a change in train frequency is less important for higher train frequencies than for lower train frequencies. As discussed in Section 3 no heterogeneity effects were tested for train frequency.

The presence of intercity services at a station is not significantly relevant compared to a station with only regional services. However, one heterogeneity effect is important (hereby domestic and international HST services are assumed to have no additional effect): if many of an office's employees regularly visit customers then the presence of intercity services is not beneficiary to a location's attractiveness. A possible explanation for this, as discussed above, is that employees may often receive a company car from their employer if they regularly visit customers. This increased car availability could lower the need for good accessibility by train.

The stated choice model allows us to estimate the impact of HST services at a station in addition to intercity services. In other European countries HSR stations exist that do not have conventional train services or only have regional train services. In the Netherlands, however, all HSR stations in the near future are stations that currently exist and where intercity services are already present.

The impact of domestic HST services on a location's utility is statistically significant but small in addition to the effect of intercity services. This is not surprising, since domestic travel distances in the Netherlands are relatively short. For the few connections on which a reasonable time gain due to HST might be expected (for example the Amsterdam–Groningen connection) the expected number of business and commuting trips is small relative to all the trips to and from offices in the Randstad area. Because of the limited effect of domestic HST services, no heterogeneity effects are estimated.

Table 3
Random parameter logit model estimation results.

Attribute	Parameter	*t*-Value[a]	Probability value
Station access time (min)			
Linear	−0.29534	−6.469	0.000
Quadratic	0.00955	1.887	0.059
Cubic	0.00292	3.354	0.001
Standard deviation (normal distribution)	0.16893	3.414	0.001
Train frequency (natural logarithm of trains per hour)			
Mean	1.17698	4.662	0.000
Standard deviation (normal distribution)	1.60687	5.237	0.000
Train services:[b] also intercity train services			
Mean	0.26878	1.108	0.268
Employees visiting customers[f]	−0.35992	−2.599	0.009
Trips to international HST destinations[d]	−0.36029	−1.705	0.088
Train services:[b] also domestic HST			
Mean	0.51026	2.289	0.022
Employees visiting customers[f]	−0.35992	−2.599	0.009
Trips to international HST destinations[d]	−0.36029	−1.705	0.088
Train services:[b] also international HST			
Mean	0.28772	1.059	0.290
Employees visiting customers[e]	−0.35992	−2.599	0.009
Trips to international HST destinations	1.92105	3.902	0.000
Standard deviation (uniform distribution)	1.97441	4.478	0.000
Station access mode (bus = 1, walk = −1)			
Mean	−1.09615	−4.814	0.000
Branch of industry	0.50260	1.928	0.054
Motorway access time (min)			
Mean	−0.35581	−5.134	0.000
Employees visiting customers	−0.17790	−1.760	0.078
Standard deviation (normal distribution)	0.29036	4.987	0.000
Parking places (number per 100 employees)			
Mean	0.04077	2.442	0.015
Employees receiving customer visits	0.06299	2.190	0.029
Price of real estate (€ per m^2 per year)			
Mean	−0.10558	−6.647	0.000
Standard deviation (normal distribution)	0.06932	5.134	0.000
Type of building[c]			
Mean	0.15486	0.845	0.398
Standard deviation (uniform distribution)	2.49138	4.919	0.000
Type of urban environment[d]			
Mean	−1.58385	−4.518	0.000
Standard deviation (uniform distribution)	4.00957	5.314	0.000
Interaction effects			
Station acc time × acc mode			
(linear)	0.04222	1.385	0.166
(quadratic)	0.00649	0.787	0.431
(cubic)	0.00008	0.078	0.938
International HST service × type building	0.44627	2.038	0.042
Number of observations	1336 (=167 × 8)		
ρ^2	0.3499		

[a] According to a two-tailed *t*-test.
[b] Effect code, "only regional trains" is reference value.
[c] "Architecturally remarkable" = 1, "Average" = −1.
[d] "City centre" = 1. "City-rim office park" = −1.
[e] Parameters for intercity, domestic HST and international HST are restricted to be equal.
[f] Compensate effect code for international HST. Parameters for intercity and domestic HST are restricted to keep them equal.

Two effects are observed for international HST services. Firstly, the model provides evidence for an image effect, which is that the presence of HST services at a nearby station can influence location choices by raising the status of a location. Because the architectural style of the building also has an impact on the status, there could be an interaction between the architecturally style of the building and the presence of HST services if the image effect is true. This interaction was actually found to be significant, which is an indirect indication that image effect exists. Secondly, accessibility by HST (so the actual use for travelling) is important but only for offices from which international business trips are regularly made. However, the large standard deviation in the RPL model indicates that besides these two effects there still remains a substantial unexplained taste variance.

In practice, a relationship exists between the presence of HST services at a station and other attributes. Foremost, offices at these locations are often more expensive than at other locations in the same region. From the telephone interview respondents (291 observations for this question) 25% would regard an HST location in the Netherlands as a viable option for their office.

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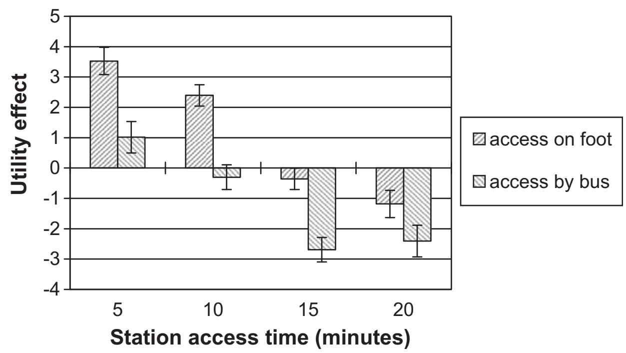

Fig. 3. Impact of station access time on foot and bus on the utility effect.

4.6. Accessibility by car

The motorway access time and the number of parking places show significant results for the mean effects and several heterogeneity effects. The number of employees receiving customer visits increases the importance of parking places. Furthermore, an office with many visitors has a relatively large need for parking places. The number of employees visiting customers also increases the utility of being located near a motorway. As discussed above, this may be partly due to a relative increase in car use.

4.7. Non-accessibility attributes

The model estimation results show a large variance in the importance respondents attach to the non-accessibility attributes included: the price of real estate, the type of building and the type of urban environment. In the current model this variance remains unexplained. This is not surprising, since the model is optimized for explaining the taste variance for accessibility attributes but not for these non-accessibility attributes. However, it is important to notice that for part of the offices the non-accessibility attributes are more important than accessibility.

5. Conclusions

This paper has focused on the question of how the level-of-service of railway stations, and in particular the presence of HST services, has an effect on the attractiveness of location for offices. A stated choice experiment was carried out to study the relevance of level-of-service characteristics for office location choices. This experiment has also provided information on how the importance firms attach to accessibility differs between types of offices and on the effect of station access on the attractiveness of locations. It has *not* been the purpose of this experiment to include other relationships or feedback mechanisms between accessibility, location choices and non-accessibility attributes of locations. Neither does the experiment allow conclusions with respect to the consequences of HSR for the total level of economic activities within the Randstad.

The model results show that international HST services can have a considerable impact on the attractiveness of an office location. There are, however, large differences in the importance of HST connectivity between offices. This taste heterogeneity can partly be explained by the importance offices attach to business trips to Belgium, Germany and/or France; these countries can be directly reached from the Netherlands by HST. A substantial part of the heterogeneity however remains unexplained.

Additional to the accessibility effect, the results show the importance of an image effect of international HSR which can be enhanced by the building and environment. This effect is considerably smaller than the accessibility effect. This is particularly relevant for the Netherlands because several Dutch cities with an HST connection are restructuring their station area, an example being the Amsterdam South axis area.

Domestic HST services are less important for location choices. This is not surprising, firstly since the distances within the Netherlands are either too small for there to be a considerable gain in travel time, and secondly because HST services are only a small portion of all business or commuting trips. The proposed domestic connections from Amsterdam to Groningen or from Rotterdam to Utrecht are therefore not likely to have a significant impact on the location choices of offices in the Randstad region. For a more peripheral region like Groningen this might be different.

The size of the area near an HSR station that is particularly attractive for offices is not strictly demarcated, but is the result of a complex combination of station access time and access transport mode, as shown in Fig. 3. Walking times up to 10–15 min are seen to be reasonable. For larger distances access by bus becomes more important, depending on its availability and travel speed. Due to the limited size of the data set, however, the model does not show whether and how the level-of-service of a station affects the size of the area of influence of the station.

The estimation of heterogeneity attributes has resulted in more insight into how office characteristics influence the relevance of the different accessibility attributes. The model results show that the travel-related characteristics of the offices – especially the frequency of trips – in general explain the differences between offices for accessibility attributes better than the branch of industry. Finally, the model shows that large differences exist between offices in the Netherlands in the relevance of accessibility by HST. This heterogeneity is partly explained by whether or not an office has employees making international business trips to countries directly linked to the Netherlands by HST. But a substantial part of the taste heterogeneity remains unexplained by the office characteristics considered and might be ascribed to the individual preferences of the respondents.

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