

## **Impact of land-side accessibility on the competitive position of airports**

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### **Summary**

In order to help airports in establishing their existing and future position, we have developed a simple strategic model that quantifies the impact of existing and future land-side accessibility scenarios. The model estimates the strength of the airport accessibility relative to its direct competitors, and indicates whether the catchment area is increasing or decreasing. Accessibility is measured not only in terms of average car travel time, like in most accessibility indicators, but also other components (travel costs, parking cost etc.) and other modes are included. Knowledge about these factors, together with knowledge about the value that air passengers attach to these factors, may help airports to assess their future position, and to identify the transport measures necessary to assist in achieving an increase in market share.

**Keywords:** airport competition, land-side accessibility, catchment area, travel time

### **1. Introduction**

Land-side accessibility is generally considered to be one of the key factors that influence the competitive position of an airport, together with the quality of the air network (destinations served, flight frequencies, airlines, average ticket price, etc.). With overlapping airport catchment areas, and expanding air services, competition between airports gets tougher. In these circumstances it is very important for an airport to know exactly how good or bad its land-side accessibility is, relative to its direct competitors. And how its accessibility by road and rail is likely to develop in the future, again relative to the expected developments for the competitors.

Existing models can not always be used for such an analysis. In the Netherlands, the Dutch National Model (LMS, Landelijk Model Systeem, see Daly 2000) includes

detailed information about surface transport to/from Schiphol, but it does not include traffic flows to the other regional airports, since these are aggregated with other flows in the same region. Furthermore, it does not include a taxi mode, which is an important access mode for airports.

Specific airport models, such as Aeolus (formerly known as ACCM, Airport Catchment area and Competition Model, see Kouwenhoven et al. 2007) include the accessibility of airports (both Schiphol and regional airports), but they focus on the impacts of capacity constraints at airports. They can be used to simulate the impact of land-side accessibility changes, but only at a high level of aggregation (e.g. average travel time changes within a region). The model that is presented in this paper combines the strong points of both types of models.

## **2. Definition of accessibility**

Most people have an intuitive feeling for the concept of accessibility. However, it is not trivial to quantify this variable. Many definitions are around. Some are simple, others are more complex. We mention here three categories of definitions:

1. Accessibility measures that only take *travel time* into account. Examples of such definitions are:
  - the distance that a person can travel within one hour from a certain location;
  - the area of all locations from/to where one can travel within one hour;
  - the number of jobs within a one-hour travel time radius.

However, these simple definitions only take part of the accessibility into account. An example of an accessibility application using this type of definition is the Dutch National Accessibility Map (“Nationale Bereikbaarheidskaart”) of Goudappel Coffeng/Transumo (<http://www.bereikbaarheidskaart.nl/>)

2. Accessibility measures that also take *other characteristics* into account, such as *travel costs, parking costs, reliability of travel times, service level*. In these measures, these characteristics are usually monetarised using a value of travel time, value of reliability, value of service level, etc. In this way, all components are converted in monetary values and can then be added together. The sum of all these values is called the “generalised travel costs”.

3. Accessibility measures that take multiple modes into account. The measures mentioned above only take a single travel mode into consideration, usually the car-mode. Accessibility measures that take multiple modes (car, train, bus, etc.) into account have to weigh the accessibility of the individual modes. This can be done by using the so-called LogSum as an accessibility measure (see e.g. Ben-Akiva and Lerman, 1985):

$$LogSum = \log \left( \sum_{i=mode} e^{-\beta \cdot GenCost(i)} \right) \quad (1)$$

where the sum is taken over all available modes.

This LogSum is a kind of inverted travel impedance: the more options you have to travel, the higher the LogSum value. Cheaper and faster options contribute more than slow and expensive options. The advantage of such a measure is that it is very good for relative comparisons (i.e. comparison of the accessibilities of different locations). A disadvantage, however, is that the absolute value by itself does not have a intuitive meaning.

### **3. Model for the accessibility of airport**

We have developed a simple model that assesses the land-side accessibility of airports, derived from the AEOLUS model system (Kouwenhoven et al. 2006). Our simple accessibility model uses level-of-service data that was generated for the Dutch National Model (LMS: *Landelijk Model Systeem*, Daly 2000). From this data, the accessibility of each airport is determined. The model calculates several accessibility measures according to the three types mentioned in the previous section.

#### **3.1 Dimensions of the model**

The model includes the seven largest airports in the Netherlands that have regular commercial flights, or are likely to have commercial flights in the near future. These airports (with their airport code) are:

Amsterdam Airport Schiphol	AMS
Rotterdam Airport	RTM
Eindhoven Airport	EIN
Maastricht/Aachen Airport	MST
Lelystad Airport	LEY
Enschede Airport Twente	ENS
Groningen Airport Eelde	GRQ

Note that for the current version of this new application, we have excluded the foreign airports. In reality, these airports also compete with Dutch airports.

The model uses the same geographical disaggregation as the Dutch national model system (LMS). In this model, the Netherlands is subdivided into 1379 zones. The boundaries of the zones coincide with the borders of the municipalities, or with the (finer) borders of the postal-code zones. The areas of the zones were chosen in such way that the number of inhabitants per zone was (roughly) constant..

The model incorporates the five most important transport modes for access to these Dutch airports: car driver, car passenger, taxi, train, and local/regional public transport (bus, tram & metro).

### **3.2 Level-of-Service data**

In order to calculate the accessibility of the airports, the model needs input on the level-of-service of for travel to each of these airports by each of these modes. Therefore, we have assembled a database with travel distances, travel times, travel costs, interchanges and waiting times for these trips (based on the situation in 2003). These data were originally prepared as input for the Dutch national model system (LMS). Car level-of-service data have been generated using the LMS QBLOK module and include congestion for each of the three time-of day periods (AM peak, off-peak, PM peak). Local public transport level-of-service data have been derived from the time tables per time-of-day period. For train the level-of-service variables are the average over all relevant routes from the origin to the destination.

### **3.3 Results: airport accessibility**

Figure 1 shows the accessibility of Amsterdam Schiphol airport according to the three different accessibility measures mentioned above. On the first row, the simple travel time is shown for two modes (car and train). For the car, the areas of equal

accessibility have a more or less circular form, while for the train the areas are more patchy as a result of the structure of the rail infrastructure network.

Accessibility according to generalised travel costs are shown on the second row in Figure 1. This includes all travel components (travel costs, parking cost, monetarised in-vehicle travel time, etc.). The exact calculation of the generalised travel costs are explained in full detail in the Appendix. As can be seen from Figure 1, the general structure of the accessibility remains the same as was seen when considering travel time alone. However, due to the high parking costs at Schiphol airport, the general levels for accessibility by car are lower than when using the train.

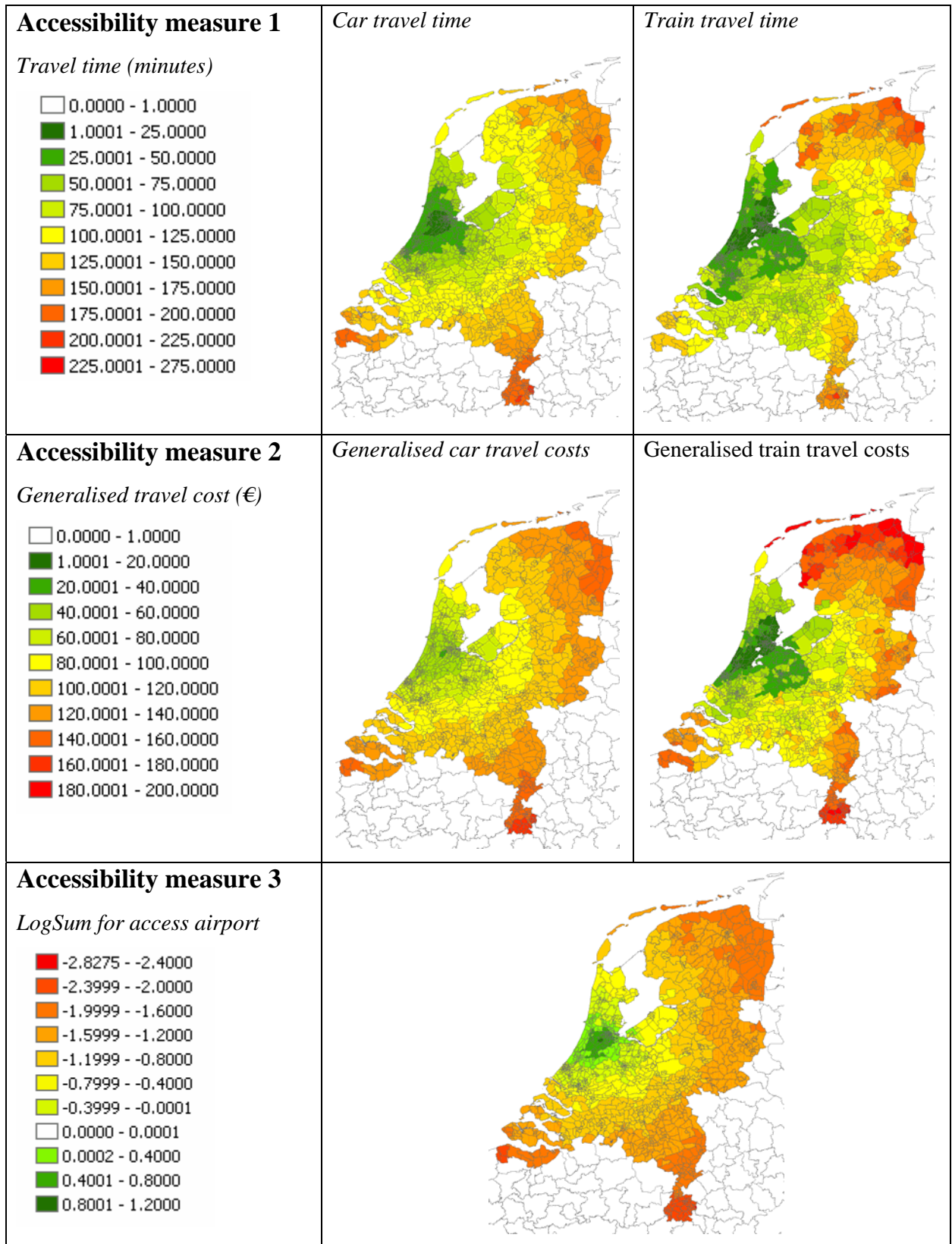
These generalised costs can be used to determine the modal shares for access to each airports. For this we use standard Maximum Utility Theory and Multinomial Logit (MNL) (Ben-Akiva and Lerman, 1985) which states the modal share is given by a logit equation:

$$\text{Modal share(mode } i) = \frac{e^{\beta \cdot \text{GenCost}(i) + \text{ASC}(i)}}{\sum_i e^{\beta \cdot \text{GenCost}(i) + \text{ASC}(i)}} \quad (2)$$

ASC(i) is the Alternative Specific Constant and represents the intrinsic attractiveness of each mode all other things being equal. These ASCs can be estimated using the observed modal shares for Schiphol (see Table 1). For our analysis, we have neglected the “Other” mode.

<b>Mode</b>	<b>Modal split</b>
Car driver	32.6%
Car passenger / carpool	12.7%
Train	34.7%
Bus	8.9%
Taxi	9.3%
Other (incl. bicycle)	1.8%

**Table 2: Modal split data for O/D passengers for access to Schiphol in 2002**  
**Source: Mott MacDonald 2003)**



**Figure 1 : Accessibility of Amsterdam Schiphol airport**

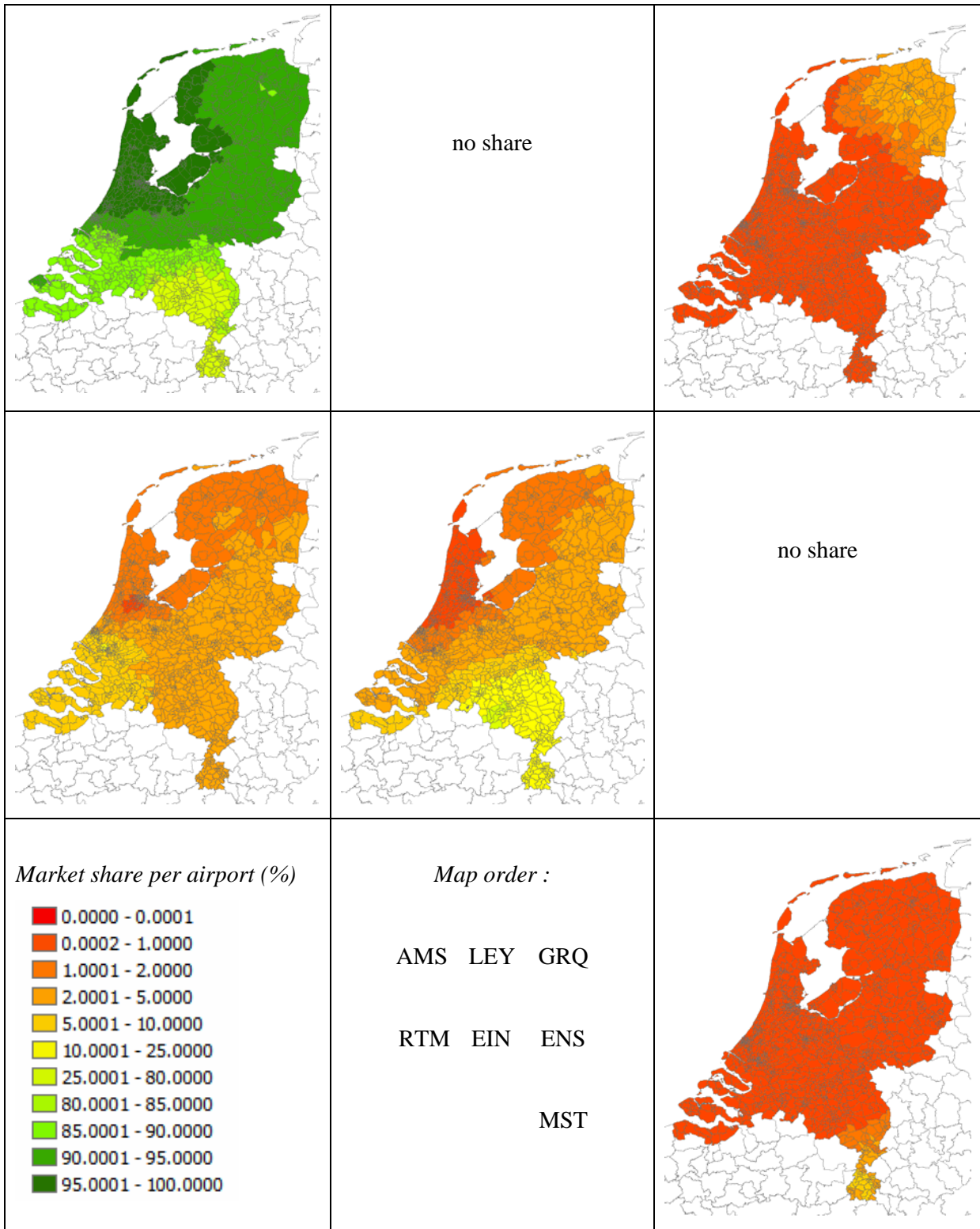
In equation (2), a summation over all modes is performed. However, not all modes are available to every traveller. Some Dutch travellers do not own a car, so the car mode is not a real alternative to them. The same holds for foreigners that make a visit to the Netherlands. They usually also do not have the car passenger alternative. Therefore, for 40% of the travellers, we have excluded these two alternatives and we have made only the remaining three modes available to them,

The last row in Figure 1 shows the accessibility according to the LogSum measure. This incorporates all (five) access modes. In order to properly weigh all modes, the Alternative Specific Constants are included in the LogSum calculation as well. Given the strong intrinsic attractivity of the car mode (for those travellers who have access to this mode), the general structure of the plot is similar to the car travel time plot and the generalised car travel cost plot. But at a more detailed level differences become apparent and this LogSum measure is much more powerful than the simple travel time calculation, since it can be used to determine the effects of changes in all modes and in all components of accessibility.

#### **4. Competition between airports**

Our simple model uses a similar logit model to calculate the market shares of each of the airports. The utility (or attractivity) of an airport is determined by its land-side accessibility (as given by the logsum accessibility measure) and its air-side accessibility (as given by the logarithm of the number of weekly flights to a certain destination). All other components that may influence the traveller's choice for an airport (such as average ticket price, the presence of certain airlines, time needed to go from the airport entrance to the gate, the shopping facilities, etc.) are included in an airport specific constant (similar to the mode alternative specific constant discussed before). Base year information on the number of passengers and number of flights were taken from CBS Statline (2008)

The results of the market share analysis are shown in Figure 2. Due to its high number of air-side connections and its intrinsic attractivity, Schiphol is dominating the Dutch market. Even in the Southern part of the country, the calculated market share of Schiphol is still quite high. Actually, this is an overestimation of the real market share, as people living in the areas that are bordering Belgium and Germany have also other airports available to them, such as Brussels, Charleroi, Niederrhein, Düsseldorf, etc.



**Figure 2 : market share for each airport**

Figure 2 also demonstrates that the catchment area of the regional airports is much more local. Given the low number of (scheduled) commercial flights at Lelystad (LEY) and Enschede (ENS), no market shares were calculated for these airports.

## **5. Case study: future scenarios**

To illustrate the capabilities of our simple model, we have used it to forecast the market shares for two hypothetical future scenarios. Both scenarios are quite extreme in order to show the shifts in market shares. The model is detailed enough to also forecast the impact of much smaller (and more realistic) changes.

### **5.1 Increasing congestion, increase of costs, decrease of travel time reliability**

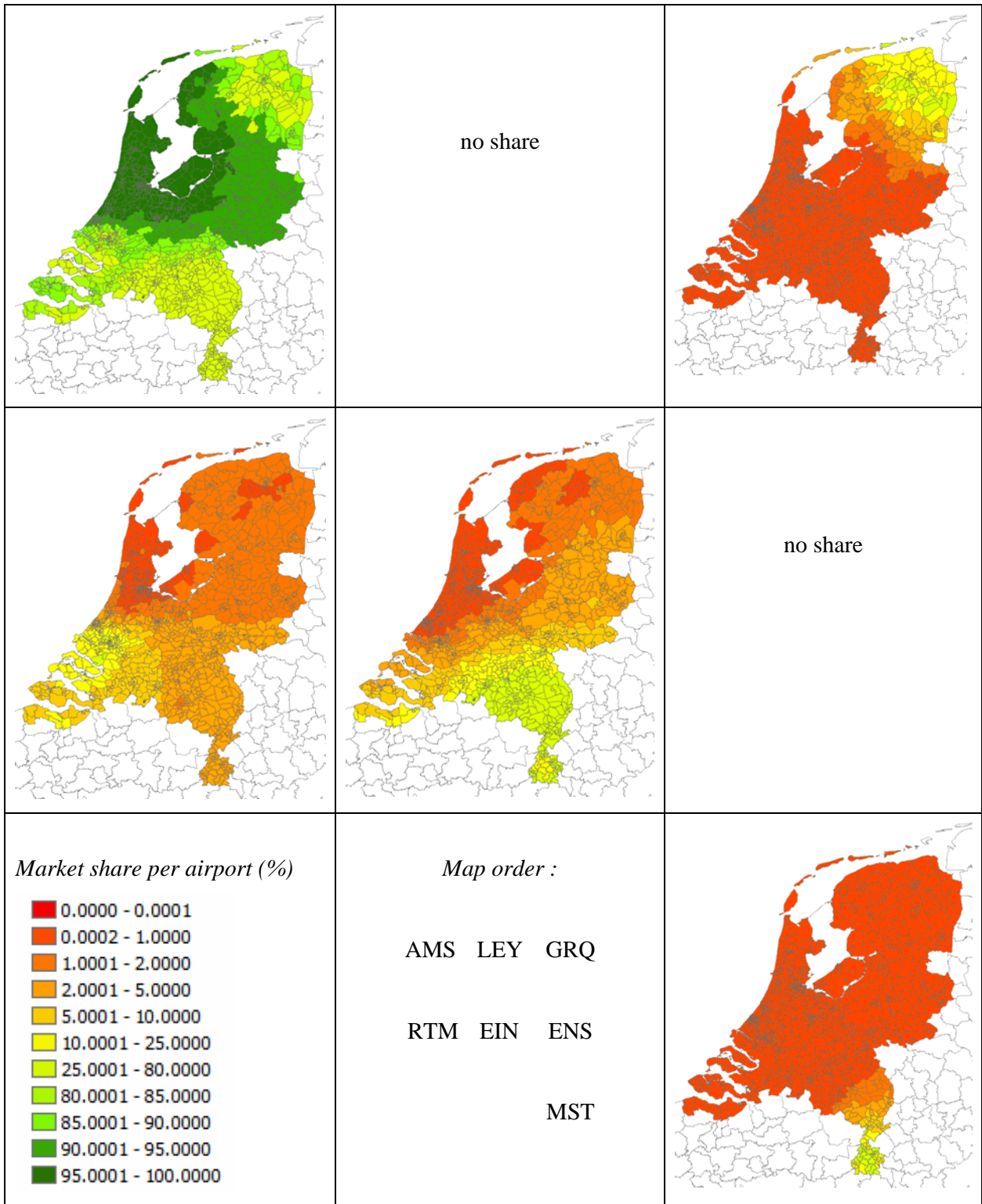
In this (extreme) scenario, we have strongly increased the generalised travel costs. This increase could be due to an increase of congestion (increased car travel times), of the oil price and/or of car travel time reliability. This affects the car driver mode, car passenger mode and taxi mode, but also the local public transport mode (since buses use the same roads as car) and the access component to the train station.

The new market shares are displayed in Figure 3. As can be seen from this figure, the catchment areas of all airports become smaller. This effect is strongest for Schiphol. This is because travellers are more likely to choose for a regional airport as a result of the longer travel times and higher travel costs.

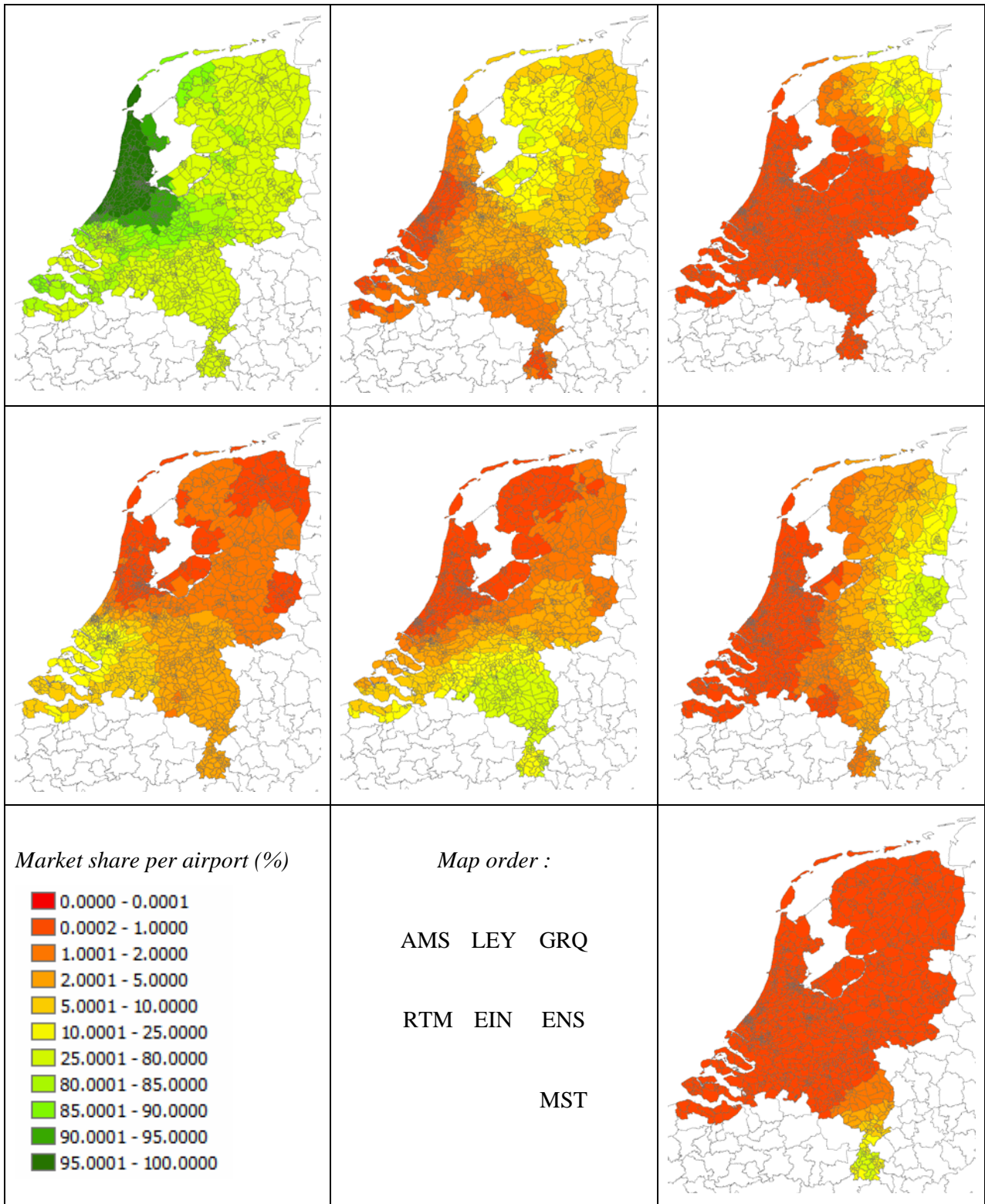
### **5.2 Introduction of new airports: LEY and ENS**

This scenario assumes the same (extreme) increase of congestion, travel costs and/or decrease of reliability as in the first scenario, but it also assumes that Lelystad airport (LEY) and Twente airport (ENS) are developed into full regional airports, with air-side connections similar to those at Rotterdam airport and Eindhoven airport.

Figure 4 shows the effects on market shares. Lelystad airport and Twente airport now attract a significant market share. Most prominent difference with the previous scenario is again the decrease of the catchment area of Schiphol. Rotterdam airport and Maastricht airport are hardly affected by these new airport developments.



**Figure 3: market shares for airports scenario 1 (increased congestion/costs etc.)**



**Figure 4: market shares for airports scenario 2 (increased congestion/costs etc. and development of LEY and ENS into strong regional airports)**

## **6. Conclusions and further research**

We have developed a simple strategic model to assess the impact of land-side accessibility on the competition between airports. The accessibility is measured using a LogSum measure, which is much more powerful than a simple travel time calculation, since it can incorporate all travel characteristics and all modes.

The case studies show the range of possible impacts of future changes in the land-side accessibility parameters, such as increasing congestion and travel costs. These can result in smaller catchment areas.

The current model is still under development. Important modifications are the inclusion of foreign airports, since these are good alternative choices for travellers living near the borders of the Netherlands.

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### **Appendix: calculation of generalised costs**

For the second and third accessibility measure, all components of the access travel need to be converted into monetary values and added together to get the generalised access costs. Only the travel to the entrance of the airport is considered. The time between the entrance of the airport and the gate also differs considerably between airports, but this is taken into account in the airport specific constants.

For the car mode, the total travel time consists of two parts: in-vehicle travel time and the time it takes to travel from the car park to the entrance of the airport. This latter time is small for the small airports, but can be more than 10 minutes for Schiphol if the long-park facility is used. For all airports the time to find a parking place is neglected. The total travel time is monetarised by multiplying the time with the average value-of-time. For access to airports, we assume a value-of-time of 30 euro per hour (average over all travel purposes)

The car travel costs consists of two components as well: fuel costs and parking costs. The fuel costs are derived from the car distance, the average car efficiency and an assumed fuel price. For the parking costs, we have collected information from all airport websites. Since the parking costs is highly dependent on the duration of the parking, we decided to take the parking cost for a single day. This is the typical price a business traveller for a one-day trip has to pay. For longer duration stays, the parking price will increase, but so does the average number of persons per car, so that the per-person parking fee remains about the same.

For the car passenger mode, only the monetarised travel time is taken into account. It can be argued that the passenger shares the fuel costs with the driver, but since we have no information about the average group size, this is neglected.

For the taxi mode, we consider the in-vehicle travel time and the taxi costs. It is assumed that the taxi will pick you up from home and drop you at the entrance of the airport, so no access/egress to/from the taxi station is needed. The taxi costs are assumed to have a fixed component and a component that is proportional to distance. The coefficients are determined by consulting taxi company websites. The distance proportionality constant decreases linearly from €2/km for short trips to €1/km for

trips over 100 km. The total trip prices that are determined in this way match the advertised values for trips to the airports quite well.

For the train mode, our database does not provide information about the component of the trip that covers the access to the first train station, except its distance. Since this could be either by bicycle, a (cheap) local bus, or by car (kiss-and-ride), the costs of this trip component are neglected. The travel time of this component is derived by dividing the distance by an assumed speed of 20 km/h. For the component of the trip that covers the egress of the last train station, we have consulted a travel planning web site (<http://www.9292ov.nl/>). Any costs of this component are neglected.

All travel time components are monetarised using the same value-of-time as for car travel. The waiting time is monetarised by using twice the value-of-time, since travellers do not like waiting time very much. Travellers also do not like any extra transfers (train-train transfers), so these are penalised as well.

The local public transport mode (bus/tram/metro) has similar components as the train mode. The trip costs are proportional to the number of tariff zones that one passes in addition to a starting tariff zone. Travellers pay them using so-called “Strippenkaarten” in which a strip has to be stamped for each tariff zone. Typical price per strip is €0,50.

The following table summarises these generalised costs equations:

Generalised Cost (Car Driver) =

- VOT \* (Travel Time Car + Time between Car park and Airport)
- + Car distance \* Car efficiency (in fuel litres per km) \* Fuel price
- + Park cost

*Travel time car, car distance taken from database*

*VOT = €30/hour*

*Car efficiency = 1 liter per 10 km*

*Fuel price = €1,50 per litre*

*Park cost (for 1 day) taken from websites*

Generalised Cost (Car Passenger) =

VOT \* (Travel Time Car)

Generalised Cost (Taxi) =

VOT \* (Travel Time Car)

- + Taxi start tariff + Car distance \* Taxi price per km

*Taxi start tariff = €3,00*

*Taxi price per km = €2,00 (short trips) - €1,00 (trips > 100km)*

Generalised Cost (Train)=

VOT \* (access distance / access speed)

- + VOT \* in-vehicle train time
- + VOT \* (in-vehicle egress (bus) time + walking time)
- + VOWT \* (waiting time)
- + TransferPenalty \* Number of transfers
- + TrainCost

*travel times, distances and costs are taken from database*

*access speed = 30 km/h*

*transfer penalty = €5,00 (equivalent to about 6 minutes of travel time)*

Generalised Cost (Local Public Transport (Bus, Tram, Metro)) =

- + VOT \* in-vehicle time
- + VOT \* (total walking time)
- + VOWT \* (total waiting time)
- + TransferPenalty \* Number of transfers
- + (Number of tariffzones + 1) \* Cost per zone

*Cost per zone = €0,50*