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Infrastructure and Urban Development; the case of the Amsterdam Orbital Motorway

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Infrastructure and Urban Development; the Case of the Amsterdam Orbital Motorway[1]

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Abstract

Orbital motorways have a strong impact on the relative accessibility of locations in urban networks. In the present paper we give a concise review of studies in this field. In addition a case study is presented with results for the Amsterdam orbital motorway which was completed in 1990. Special attention is paid to impacts on office rents and on responses of firms with respect to the benefits they received due to the completion of the orbital motorway.

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[1] This study is based on Bruinsma, Pepping and Rietveld (1993). The research project was funded by the Transportation and Traffic Research Division, Rijkswaterstaat, Rotterdam.

1. *Introduction*

The first European motorways were realized in countries such as Germany and Italy in the 1920's. In the 1930's these motorways were extended into interregional networks connecting cities at considerable distances. During this period also the first orbital motorways were planned around cities such as Berlin, Munich and London. It took a long time to complete these orbital motorways, and some of them were even never completed. As Hall (1990) indicates the major reason for the planning of the European orbital motorways was not just the desire to remove traffic congestion. At that time roads were not yet very congested in Europe. Other motivations to build orbital motorways were the desire to reveal and reinforce the organic spatial structure of cities, and to make monumental artefacts which could serve nationalistic purposes.
After the Second World War road traffic started to grow at a very rapid rate in many European countries and this has induced the creation of orbital motorways in many countries. Orbital motorways have various types of impacts on metropolitan areas including direct impacts on traffic and impacts on the spatial structure of activities. We know much more about the first type of effects compared with the second type of effects (cf. Bruinsma en Rietveld, 1992). It is for this reason that we have decided to focus on the second types of effects in this contribution.
This paper is structured as follows. In section 2 we present a concise survey of research results in the field of impacts of orbital motorways. Section 3 gives information on the completion of the Amsterdam orbital motorway in 1990 and the observed effects on traffic flows since then. Expert opinions of the impact of the orbital motorway are given in section 4. Effects of the orbital motorway on office rents are discussed in section 5. Responses of firms, based on a stated preference approach are discussed in section 6. Concluding remarks are made in section 7.

2. *Analyzing Impacts of Orbital Motorways*

Changes in highway networks lead to various types of changes in the behaviour of (potential) network users:

- timing of trips
- routing of trips
- choice of transport mode
- choice of origin or destination of trip (trip distribution)
- trip frequency

These changes which take place in the sphere of transport will in their turn have wider economic and spatial impacts. A reduction in generalized transport costs will lead to a higher productivity in economic activities, not only because transport costs as such decrease, but also since indirect gains can be realized by adjustments in logistics and because it leads to a better fuctioning of the labour market. The increase in productivity leads to lower consumer prices, higher factor prices (including prices of land) or combinations of these. Spatial effects will occur since the accessibility gains due to the improvement of the transport

network are not distributed evenly in space. One may expect spatial relocation of economic activity, accordingly (Rietveld, 1993).

A usefull summary of research on impacts of highway improvement is given by Bonsall (1991). He finds that the impacts depend strongly on a number of important conditions such as the size of the improvement, the pre-existence of suppressed demand, present levels of congestion, present network density and local economic conditions. For these reasons one may not expect simple generally applicable answers to the effects of highway improvements. For the transport behaviour components mentioned above Bonsall finds the following effects of road transport improvement:

- In previously congested areas it is not uncommon that substantial numbers of drivers return to the peak period.
- Route changes may vary from zero to as large as 60 percent in particular cases.
- Changes in transport modes depend strongly on the pre-improvement share of public transport.
- Short term changes in the choice of origin or destination are limited; maybe around 5% of the trips using the improvement has changed in origin or destination.
- Changes in trip frequencies (new traffic) are expected to come about in the long run. There is much uncertainty about their exact size, however.
- Uncertainty on land use effects are even larger because it is often difficult to say to which extent observed changes in land use are really caused by network improvements.

The above results relate to highway improvements in general. In the case of orbital motorways the type of improvement is more specific so that one may hope to arrive at more definite results. An important feature of orbital motorways is that they make route choice much more flexible. When traffic would be blocked on one part of a ringroad one can still use the other parts of this road to reach any destination desired. In the case of orbital motorways one can distinguish three types of use:

1. use for intra-urban trips,
2. use for trips from outside the urban area to inside, or vice versa,
3. use for trips with both origin and destination outside the urban area.

With type 1 effects the attention is focussed on the role of orbital motorways within the urban network. These effects depend strongly on the existing intra-urban network. In the case of type 2 effects the accessibility of the urban area from the surrounding regions is the major concern. In the case of type 3 effects the role of an orbital motorway in a larger interregional network is taken into account.

The relative importance of the three types of use will vary considerably among cities. In some cases an orbital motorway may be of large importance for the accessibility of regions in a large interregional network. In other cases its dominant importance may be as a relief for congestion within cities. The balance

between the two effects depends strongly on the radius of the orbital motorway: when it is small the type 1 use will be most important, when it is very large the type 3 use will become important. The lack of attention paid to the radius of orbital motorways may be one of the reasons why research on the effects of the construction of these motorways does not lead to unambiguous outcomes.
Another important factor which has to be taken into account is that it is not always well defined how one measures the impact of an orbital highway. Does one take the impact of the whole motorway, or only of the last part which was completed many years after important parts of the motorway were already taken into use. In some countries the time between the use of the first part and the final completion of an orbital motorway may be as long as 25 years. Still another factor which makes it difficult to compare the impacts of orbital motorways at different places is that the zero-situation may vary strongly. In one case there may have been already a reasonable road connection before the orbital motorway was constructed. In other cases the construction of an orbital motorway may have a much more revolutionary impact, for example when it involves the replacement of ferry services by a tunnel or bridge.
Choice of transport mode is an interesting theme in the case of the construction of orbital motorways. Rail transport connections usually have a star-shaped structure. As a consequence many rail transport users have to travel via the centre which gives rise to substantial detour factors and time losses when one has to change trains. The construction of orbital motorways leads to an adjustment of the road network away from a star-shaped structure. This means that travel time gains may be substantial, especially when the destination of the trip is not in the centre of the city. Thus the construction of orbital motorways leads to a deterioration of the competitive position of rail transport especially in criss-cross trips.

A study on the accessibility effects of the M25 London Orbital Motorway was carried out by Linneker and Spence (1992). The M25 was built between the years 1975 and 1986. It is located in the green belt around London and with a radius of some 26 kilometers it clearly has the character of an outer ringroad. In terms of accessibilities based on travel times, the construction of the M25 has led to relatively large improvements in those parts of South East England through which the road passes (increase more than 10%). For inner London there is almost no change in accessibility. For regions further away a moderate but certainly not negligeable improvement can be observed (1-5%). Changes in route choice due to the construction of the M25 usually lead to longer though quicker routes so that when generalized transport costs are taken into account the improvements in accessibilities are less pronounced and may even become negative. These results depend strongly on the coefficients for time and vehicle operating cost used in the generalized transport cost calculations.
Given the result that accessibility changes due to orbital motorways may be substantial, one may wonder what relocation effects will occur. Such effects are not studied by Linneker and Spence (1992), but in other studies attempts have been made to estimate them. Guiliano (1986) reports about a broad survey of

effects of beltways in USA metropolitan areas. The effects are on average smaller than one might expect: the strongest conclusion possible is that beltways can have small though significant effects on regional development patterns and the economies of central cities.

Rather undecisive results are found in a comparative study of integrated transport-land-use models (Webster et al., 1988). Simulations with models developed for cities in a number of countries (Germany, Great Britain, Japan, Spain) indicate that the overall decentralizing effects of orbital motorways on the location of residences and workplaces is small compared with the effects of autonomous changes in land use patterns. The uncertainty in the outcomes may be due partly to the differences in the radius of the ringroads in the cities.

A more precise analysis is carried out in Dasgupta and Webster (1992), where a distinction is made between an outer ringroad with a large radius and an inner ringroad with a small radius. Based on a comparative study in three cities (Leeds, Bilbao and Dortmund) the authors find no clear results on a centralizing or decentralizing effect of an outer ringroad on the distribution of employment or population (see Table 2.1). A possible explanation is that the results of the model simulations depend on where the new road is located in relation to the boundary of the study area. This underlines the importance of having a sufficiently large study area in analyses of this type. An inner ringroad appears to have a weak centralizing tendency. As Dasgupta and Webster note, these rather small effects may be due to the fact that the three cities considered have already relatively well developed orbital links. One should be aware that the effects reported in the Table relate to the average outcome for the whole area. Thus although ringroads only have small effects on the average degree of decentralization in an urban area, their effects on particular zones may of course be much larger.

The result on trip distances and trip times indicates that outer ringroads lead to longer trips in terms of distances travelled, but to shorter travel times, so that average road speeds increase.

Table 2.1 Effects of ringroad investments (percentage change)

	new investment in	
	outer ringroad	inner ringroad
mode share:		
car	0.3	0.2
public transport	-0.2	0.0
walk	-0.8	-0.3
mean trip:		
distance	0.9	0.0
time	-1.2	-0.7
road speed	0.2	-0.1
distribution of:		
population	?	?
employment	?	weak centralization

Source: Dasgupta and Webster (1992)

Lathrop and Cook (1990) indicate that the spatial distribution of economic activities in the USA has been influenced by major factors such as the desire to live in spacious single-family houses and the growth in car ownership. This has induced suburbanization tendences which would have occurred even when no beltways would have been built, but beltways certainly have acted as catalysts for such a development.

3. *The Amsterdam Orbital Motorway*

3.1 Introduction

Like most of the capital cities in European countries Amsterdam suffers from traffic problems. Not only the city is confronted with large flows of traffic but especially in the peak hours the roads near Amsterdam are heavily congested. During the past decades the inner city of Amsterdam with its rings of canals has provided insufficient capacity for the growing car traffic. Partly as a result of these traffic problems companies moved out of the inner cities to the suburbs, where large office buildings were constructed. Especially the south-eastern, southern and south-western part of the agglomeration were in favour as locations for those companies. Government policies to guide the suburbanization of population went into another direction, however. For over two decades government planned - by own housing programs and restricted allowances to build anywhere else - complete residential cities at some distance from the large cities in the Netherlands. It were especially locations north of Amsterdam which were selected for the construction of large numbers of dwellings. However, the growth of employment in these new cities stayed far behind the expectations of the government. This led to an increasing imbalance on local labour markets and an increase in commuting distances. As a consequence, one of the main traffic problems is the crossing of the river IJ which is splitting Amsterdam just north of the inner city into two parts. This crossing is important since a large flow of commuters is travelling every day from the residential areas north of the river IJ to the employment centre in the southern part of the agglomeration. But also on other roads giving access to Amsterdam severe traffic problems have arisen.

So, both the housing program and the shift of employment from the centre of the city to the southern part of the agglomeration caused the need for an orbital motorway in the Amsterdam region to make the necessary cross agglomeration trips possible. The orbital motorway was constructed in several phases, partly using existing motorways. Major parts were already completed in the 1970's and 1980's. In September 1990 the last part of the Amsterdam orbital motorway - the Zeeburger tunnel under the river IJ - was completed (see Figure 3.1). With a radius of about 5 kilometres, the Amsterdam orbital motorway has the character of an inner ringroad: important parts of the agglomeration are located outside the ringroad circle.

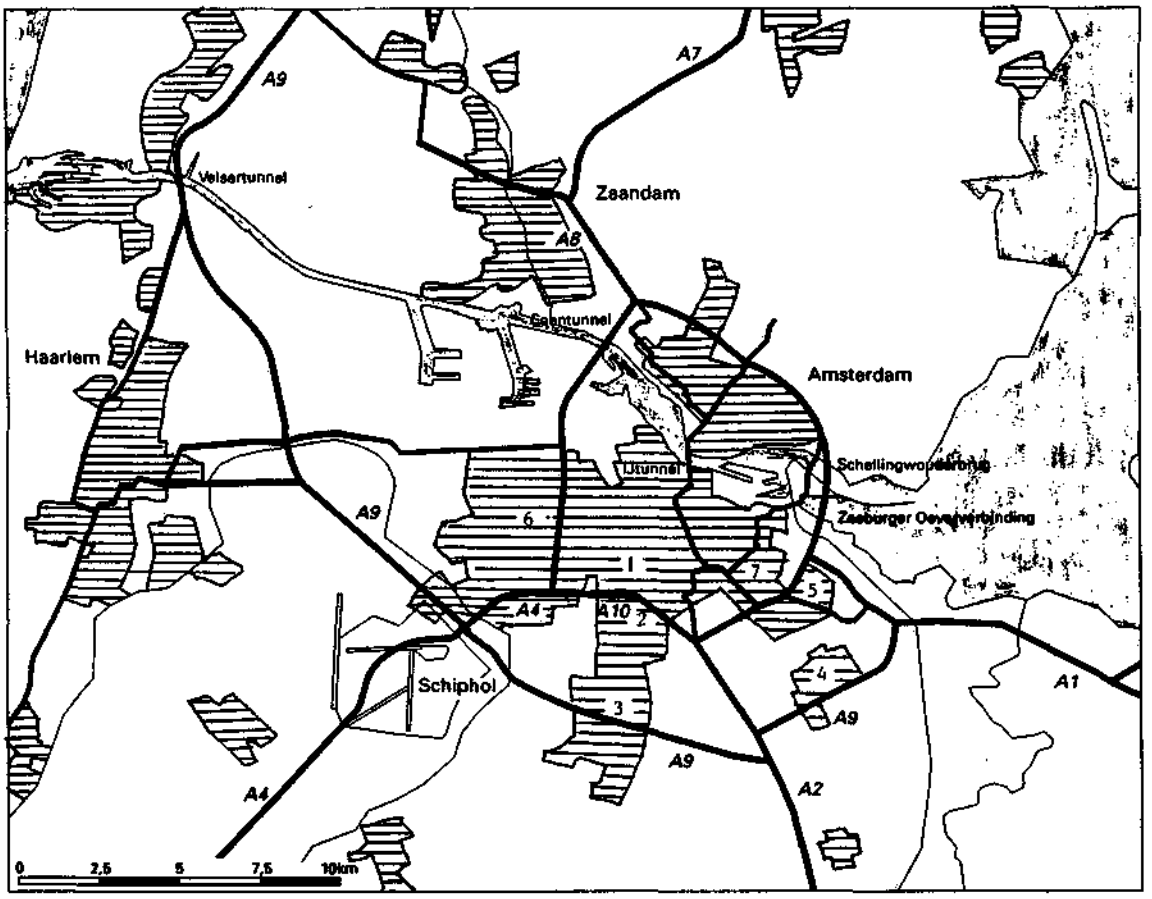
The orbital motorway has three functions:

- improvement of the accessibility of Amsterdam and the province of North Holland to the region north of the river IJ

- relieving the secondary road network in the Amsterdam region
- creating improved conditions for the economic development of the Amsterdam region

In this section we will concentrate on the first two topics. They concern effects which can measured in the short run. Research on these topics has been done by several institutes and traffic consultants under supervision of the Ministry of Transport and Public Works. The latter sections focus on the last topic and contain own research.

Figure 3.1 Map of the Amsterdam agglomeration



1 = Amsterdam-South 2 = Buitenveldert 3 = Amstelveen
4 = Amsterdam-Southeast 5 = Diemen 6 = Amsterdam-West
7 = Amsterdam-East

In this section the following effects of the completion of the orbital motorway on traffic flows will be discussed [2]:

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2 In this section intensive use has been made of: Rijkswaterstaat (1992), Effects of the Opening of the Amsterdam Orbital Motorway: Final Report Phase 1, Transportation and Traffic Research Division, Rijkswaterstaat, Rotterdam.

- effects on the traffic volumes
- effects on travel behaviour
- effects on congestion

These results are based on large scale measurements in the road network in Amsterdam before and after the opening. In addition, several surveys have been carried out among residents in the region.

3.2 Effects of the opening of the orbital motorway on the traffic volumes

The opening of the Zeeburger tunnel as final part of the orbital motorway leads to a hugh increase in capacity of the regional road network, especially concerning the crossing of the river IJ. The new connections make it possible to pass Amsterdam on the eastern side. For a number of relations this means a decrease in travel distance and/or travel time.

The total number of kilometres driven in the Amsterdam region increase slightly faster compared with the induced traffic volume for the whole of the Netherlands (0.5 to 1.0 % in the Amsterdam region compared with 0.1 to 0.2 % in the Netherlands). This increase is the result of an increase of the number of kilometres driven on the main road network. The secundairy road network of the Amsterdam region has been relieved. For instance, the number of kilometres covered by traffic crossing the river IJ on the highways increased with 13 %, while the number of kilometres made by river crossing traffic on the other roads decreased with 33 %.

In the Amsterdam region one can observe a clear shift of traffic flows in easterly and northerly directions. The traffic density on the soutern en western highway decrease within a range of 9 till 29 %. On all the existing river IJ waterway crossings traffic density dropped as a result of the opening. Per day 58.000 motor vehicles go through the new Zeeburger tunnel.

3.3 Effects of the opening of the orbital motorway on the traffic behaviour

The possibility to pass Amsterdam on the eastern side has led to a major shift in route choice. Of the car drivers who cross the river IJ 25 % have changed their choice of waterway crossing point. The Zeeburger tunnel now has a share of 19 % of all motor vehicles that cross the river IJ. Because of the changing routes towards the use of the orbital motorway, Amsterdam's city road network has been relieved.

Of the car drivers who cross the river IJ, 31 % changed their time of departure (either earlier or later). Before the opening they were forced to travel at times less suitable for them mainly because of congestion. Since the opening of the orbital motorway they can select their time of departure more according to their individual preferences. This means that, individually, drivers are benefitting. The changes in departure times have led to a 16 % increase in the number of crossings of the river IJ by drivers in the morning rush hour between 7.00 and 9.00, the so-called 'return-to-the-peak' effect.

The opening of the orbital motorway has caused minor changes in the frequency of journeys, the destination of journeys and the transport mode choice for journeys crossing the river IJ. For instance the opening has led to an increase of

1 % for commuter traffic and 5 % for traffic with other purposes (shopping, leisure, social visits).
The opening of the orbital motorway has made visible a latent demand for crossings of the river IJ in the rush hour. Here it largely concerns changes within existing traffic patterns. Travellers mainly adjust their route and time of departure, often in combination. The number of daily journeys on the waterway crossings increased by 4.5 % due to the opening. Of this 1.5 % are journeys which existed before the opening; 3.0 % were caused by journeys generated by the opening.
Only small changes were observed in the use of the different transport modes (car driver, car passenger, user of public transport). This limited change in the transport mode corresponds to daily changes in behaviour that would have occured without the opening. The public traffic flows accross the river IJ have hardly been influenced or not at all by the opening of the orbital motorway.

3.4 Effects of the opening of the orbital motorway on congestion

Considerable journey time gains have been recorded for through journeys using the main road network in the Amsterdam region. The largest gains refer to journeys between the Province of North Holland north of the river IJ and the Centre of the Netherlands. Travel via the 'old' routes also takes less time as a result of a congestion level that has decreased almost everywhere.
The reduction in the total time lost due to congestion on the entire main road network in the region is 20 %. This is the result of extra capacity and of the changes of route due to the opening. Because of the changes in the choice of departure time ('return-to-the-peak' effect) this reduction is less than what might have been expected on the basis of the increase in capacity. In the existing tunnels - Coen, Velser and IJ - the total loss of time due to congestion decreased by 39, 58 and 100 % respectively.
One must bear in mind however that the total journey time losses due to congestion are relatively small in the Amsterdam region; we guess that they are not larger than 5 % of total travel time (Bruinsma et al, 1993). Thus, the gain in total journey time due to the reduction of congestion is about 1 %.

4. The Effects of the Orbital Motorway by Expert Judgement

What will be the impact of the completion of the orbital motorway on the economy in the Amsterdam region? This question will be addressed in the rest of this paper. At the time the research for this study has been carried out (1992) the ringroad had only recently be completed (september 1990). Thus, if we assume that anticipation has not taken place, time for major adjustments has been short. Therefore we start with a survey of expectations of experts (section 4). In section 5 an analysis is carried out of rental values in the office sector. The advantage of using rents is that these can adjust in the short run whereas construction activities only take place in the long run. Finally, section 6 is devoted to a survey among entrepreneurs about the actual use of the ringroad, the impacts of the completion on firm performance and the effects they would

anticipate if the ringroad would not have been completed. A detailed account of research results can be found in Bruinsma et. al., 1993.

In order to obtain a preliminary view on the potential effects of the orbital motorway on firms, an exploratory survey has been held among various experts in the field of firm location in the Amsterdam area. These experts are amongst others real estate agents, representatives of public agencies involved in spatial planning and managers of firms that are located in the neighbourhood of the orbital motorway. Some specific issues were raised to detect the potential advantages for existing firms and factors influencing the location pattern of offices in the Amsterdam area. These issues concerned the overall view of the benefits of the new road to the area, the main advantages to the firms, dominating factors playing a role at firm location decisions, and differences in benefits between the various districts.

The experts views on the dominating location factors for firms in the Amsterdam area can be summarized as follows:

- In general, the attitude of firms towards the public transport network seems to have slightly improved (under influence of the municipal transport policy). In particular cases firms indeed tend to locate close to new tram or metro stops, as can been seen from the completion of the extension of the metro network to the southern part of the agglomeration. In this respect, the completion of the southern part of an orbital railway in the Amsterdam area in 1993 will reinforce the location effects of the orbital motorway.
- Plans for other road network extensions have to be considered as well. A new road connecting Schiphol airport strategically with the western harbour area has already in a few cases led to anticipations by property developers.
- The nature of the municipal land policy may cause firms to migrate to surrounding municipalities.
- Investments in telecommunication infrastructures may have significant influences on firm locations, as could be observed in the past in Amsterdam South-East.
- The nearness of attractive living areas and green areas is also an important factor, which is the case in Amsterdam-South and the municipality of Amstelveen.
- As in other European cities, subjective factors are of crucial importance on the office market in Amsterdam. The supply side of this market is risky, which causes imitation effects: property developers tend to build close to sites that have proven to be succesful. These imitation effects also occur at the demand side of the office market. Succesful areas develop a level of status, which is reflected in high office prices. The attraction of such a status may outstrip the relative influences of other office location factors.
- It is foreseeable that the measures of the municipality of Amsterdam

after a referendum in 1992 on the prohibition of cars in the inner city may enlarge the relative attractiveness of locations in the orbital motorway area.

In general, the experts consider the completion of the orbital motorway as a significant improvement of the Amsterdam transport infrastructure. It is expected that in particular car traffic with business purposes will benefit. Since the accessibility by car is a main location factor for the upper segments in the office market, from this point of view there is the feeling that relocations might occur in these segments.

There is quite some optimism with regard to the potential advantages to firms due to the ringroad completion. A location factor that in recent years has become important, especially in the case of large office buildings, are promotional advantages obtained from being situated at sight locations close to motorways. Another important issue is the space created for industrial and office activities, that the new areas near the orbital motorway can offer to expanding firms. By the end of the eighties, when the economy was recovering, some important expanding office and industrial firms in the inner city of Amsterdam experienced shortages of office space and moved to locations near the orbital motorway. Thus, the area of the orbital motorway has proved to be attractive to dynamic firms. At the moment about 40% of the firms in Amsterdam have logistic problems caused by lack of space while about 10% of these firms intend to move to another location, which again underlines the attraction potential of the new road.

The consequences of the completion of the ringroad for the various districts are hard to predict. One might expect that most benefits will be generated in those areas where the newest part of the orbital road are completed, which are the northern and eastern districts of Amsterdam. In particular the Northern district has always suffered from a low perception by entrepreneurs because of its separation of the rest of the city by the river IJ. Experts are convinced that the perception of these districts will improve by the new infrastructure. However, in contrast to a better accessibility of Amsterdam North by road stands the absence of an adequate public transport means connecting the centre of Amsterdam with this district. Therefore, it is doubted whether improved perceptions will lead to additional firm locations. A lesson from the past can be drawn with the construction of the Coen Tunnel connecting Amsterdam North with the southern part of the city on the west axis of the agglomeration. The completion of this part of the orbital motorway infrastructure did not result into a significant number of firm locations in Amsterdam-North.

The meaning of the orbital motorway for Zaanstad, an agglomeration west of Amsterdam that is oriented on industrial activities, is probably small. It is argued that the existing Coen Tunnel connecting this area with Amsterdam continues to be considered as a traffic bottleneck in the perception of entrepreneurs. For Schiphol airport the completion of the orbital motorway is of indirect importance only.

On the office market in Amsterdam sites in the southern part of the agglomeration, and in particular some sites near the orbital motorway, are developing to high status areas. Beside the presence of the orbital motorway main contributing factors to this development are the influence of the airport Schiphol with at the same time the closeness of the city centre by means of good transport facilities. Since in recent years an excess supply of office buildings evolved in the Amsterdam area experts do not expect a substantial shift in the spatial pattern of office market in the short run due to the opening of the orbital motorway. In the next section we confront these expert opinions with data on actual developments.

5. *The Effects of the Orbital Motorway on the Office Market*

An indication for the potential of suburban areas to attract new firms and to develop in a broader economic sense can be found in their popularity as location sites for offices. The development of prices of absorbed office space is a proper indication for this popularity because it reflects to a certain extent the willingness to pay of entrepreneurs for specific sites. The advantage of analyzing prices of absorbed office space relative to office construction decisions is the fact that the first prices reflect latest changes in market preferences while the latter are in this respect delayed in the time. The opening of the orbital motorway might increase the willingness to pay in some specific areas along it, because of cost reductions by improved logistic organization, more punctuality in deliveries of goods, an extension of the geographical labour market, promotional advantages in the case of sites that are visible from the motorway (sight locations), and so on.
For a series of three years, two before the completion (1987 and 1989) and one after the completion of the orbital motorway (1991), data on transaction prices of offices larger than 500 m^2 on the Amsterdam office market were collected. These prices were analyzed in relation to the distances of the buildings to the orbital motorway. Two techniques were used: an impact analysis and a regression analysis.

In order to assess the effects of the orbital motorway on office prices, it is important to make a distinction between suburban districts in which (a part of) the orbital motorway already was located before the completion, and suburban districts that were made accessible by new parts of it. The first group of districts includes Amsterdam-West, -South, Buitenveldert and Amstelveen, the second group includes Amsterdam-North, -East, -South-East and Diemen (see Figure 3.1).

For the areas in which distances to the orbital motorway did not change average prices of office space, classified according to the distance by road from the respective sites to the nearest ramps of the orbital motorway are given in Table 5.1. A distinction has been made between locations at less than 2 kilometres and locations at more than 2 kilometres distance from the orbital motorway.

Table 5.1 Number of transactions and average prices per m² (in Dutch guilders) of new offices on locations of which the distance by road to the orbital motorway did not change by the opening, per city district

distance to the orbital motorway	1987		1989		1991	
	no.	price	no.	price	no.	price
< 2 km.	22	250	35	256	28	294
> 2 km.	36	212	61	220	53	264
all locations	58	230	96	239	81	273

In the areas where distances did not change, office space absorbed between the years 1987 and 1991 shows a significantly higher price at sites within a limited distance from the orbital motorway compared with sites further away. Office prices increased considerably in these areas between 1989 and 1991, i.e. during the period in which the orbital motorway was opened.

The development of office prices in zones where the distance to the orbital motorway had changed due to its completion is given in Table 5.2. This Table shows the average office prices for various zones distinguished according to the decrease in distance to the orbital motorway.

Table 5.2 Number of transactions and average rent per m² (in Dutch guilders) of new offices on locations of which the distance to the orbital motorway decreased by its completion

decrease in distance 1991 compared with 1987	1987		1989		1991	
	no.	price	no.	price	no.	price
< 1 km	7	125	9	204	4	147
1 - 2 km	12	237	27	238	16	238
> 2 km	4	197	7	211	7	217
all locations	23	208	43	222	27	224

What strikes most in Table 5.2 is the fact that office prices in zones that profited most of the new orbital motorway practically did not rise between 1989 and 1991, when it was completed. They stayed behind the development in the areas of which the accessibility was not affected by the new segment of the orbital motorway. Apparently, an improvement in the accessibility of certain areas due to the ringroad construction has until now not led to a stronger competitive position of these areas in relation to the western and soutern parts of the agglomeration. However, as mentioned, the timing of this research may have been too early after the completion to detect these effects.
The conclusion to be drawn is that as far as the completion of the orbital motorway has influenced office prices, this influence is not observable in those areas where the new segments were constructed.

The impact of infrastructure on office prices can also be studied by means of regression analysis on basis of individual transactions on the office market.

Together with the influence of the orbital motorway, also the influences of the existing rail infrastructure and the metro network have been analyzed, including the extension of the metro network in 1990. In the regression model the assumption has been made that office prices are dependent on the following locational factors:

- the distance by road from the office location to the nearest orbital motorway ramp
- the walking distance from the office location to to the nearest railway station
- the walking distance from the office location to the nearest metro station.

One has to take into account the influence of status aspects. Also the quality of office buildings is an important factor determining office prices. In this respect must be mentioned:

- quality of the construction
- possible alternative use of the building
- the ratio between gross and net office space
- the representativity of the building
- the level to which the building meets specific user requirements. For example, telematics infrastructure puts a new dimension to the user value of the building.

Especially the latter two have become more and more important in recent years. Together with governmental policies like subsidies and land taxes, these factors may lead to high variations in office prices in the Amsterdam area.
A simple linear regression model that has only the distance by road to nearest orbital motorway ramps as an explanatory factor for office prices, has the following form:

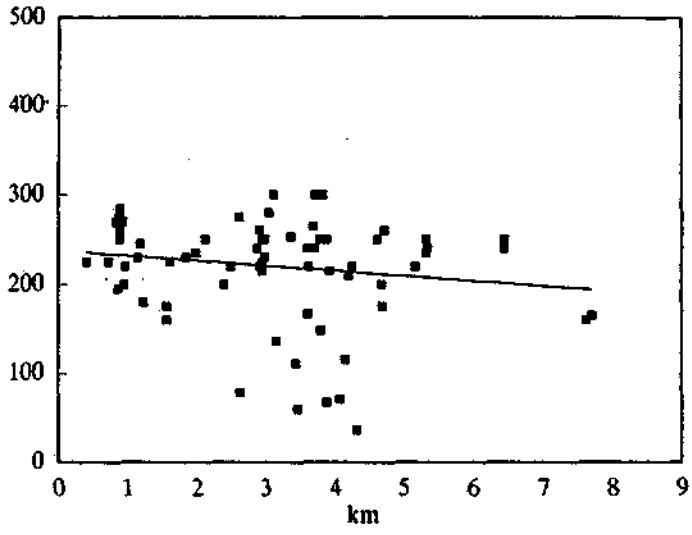
$$y_n = \alpha_0 + \alpha_1 x_n$$

whereby y_n = price per m^2 of office space taken into use on site n
x_n = distance by road from site n to the nearest orbital motorway ramp.

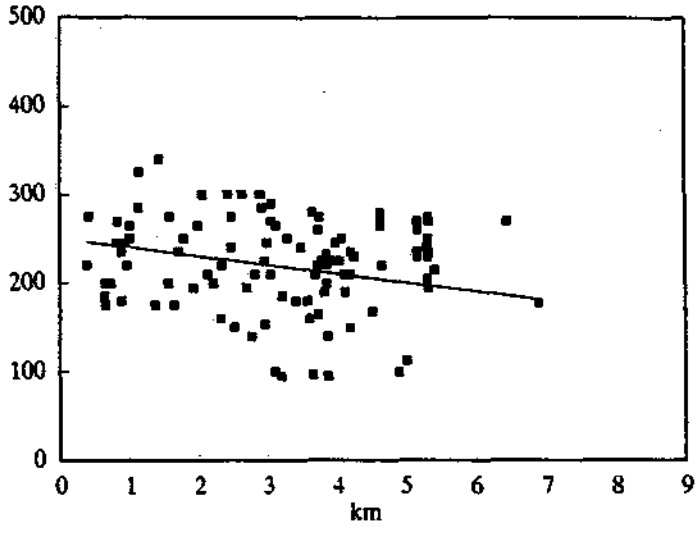
In Figure 5.1 the variation in office prices relative to their position to the orbital motorway are shown for the years 1987, 1989 and 1991. Except for the fact that the variation becomes wider in the investigated period, it appears that in all three years office prices are negatively correlated with the distances to the orbital motorway. The angle of the regression line slightly increases in this period, which could stress a growing influence of the orbital motorway. In 1991, in which year larger price differences occur than in 1989, top level prices clearly increase when distances to the orbital motorway decrease.

Figure 5.1 Variations in office prices at locations in the Amsterdam agglomeration for the years 1987, 1989 and 1991, by road distance to the nearest ramp of the orbital motorway

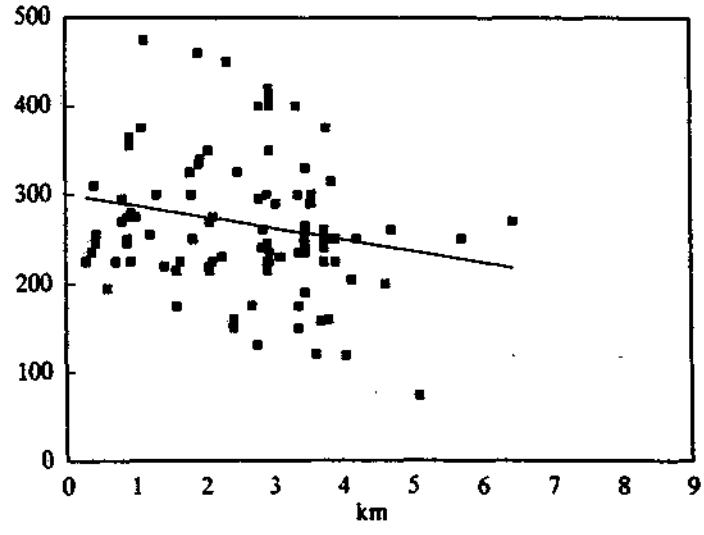
1987



1989



1991



A more sophisticated regression model incorporates the influences of the rail and metro networks in Amsterdam. In order to correct for the influence of non-infrastructural factors on office prices, the quality of office buidings and area status influences are also counted for. As an indicator for the quality of office buildings has been taken the age of the buildings. In this respect a distinction has been made between (old) existing buildings that get new users and (new) buildings, either newly constructed or renovated. In order to deal with status aspects, a distinction has been made according to the various districts. These factors can be added to the model by formulating them as dummy variables. The resulting model has then the following form:

$$y_n = \alpha_0 + \alpha_1 x_{1n} + \alpha_2 x_{2n} + \alpha_3 x_{3n} + \alpha_4 d_{1n} + \alpha_5 d_{2n} + \alpha_6 d_{3n} + \alpha_7 d_{4n} + \alpha_8 d_{5n} + \alpha_9 d_{6n} + \alpha_{10} d_{7n} + \alpha_{11} d_{8n}$$

whereby
- y_n = price per m^2 of office space at site n
- x_{1n} = distance by road from site n to the nearest ramp of the orbital motorway
- x_{2n} = walking distance from site n to the nearest railway station
- x_{3n} = walking distance from site n to the nearest metro station
- $d_1..d_7$ = dummy variables that determine the location of the sites in one of the respective districts Amsterdam-South, Buitenveldert, Amstelveen, Amsterdam-South-East, Diemen, Amsterdam-West and -East
- d_8 = dummy determining whether the concerned buildings are old existing or newly constructed/renovated buildings.

The more complete model is clearly superior to the simple model formulated above (see Table 5.3). The orbital motorway appears to be a robust explanatory factor. The coefficient of -23 in 1991 for example means that - other factors kept constant - the price of office space near to a ramp of the orbital motorway is 23 guilders per m^2 higher than on locations 1 kilometre away. The role of public transport networks is not clear. In 1991 railway stations have a slightly negative coefficient, while metro stations have a positive coefficient. Standard errors of both coefficients are high. The coefficients of the dummy variables for the various districts confirm the higher status of Amsterdam-South, Buitenveldert and Amstelveen in relation to other office sites in the Amsterdam area. For example, the average office price per m^2 in Amsterdam-South in 1991 is 63 guilders higher than in the Centre, other factors keeping constant. The influence of the quality of office buildings is also clearly confirmed. In 1991 the average price of new (or renovated) office buildings is 37 guilders higher than the price of existing offices.

The overall conclusion to be drawn from this quantitative analysis of prices on the Amsterdam office market is, that although the effects are not directly visible in the areas where the new segments were constructed, in general the orbital motorway is an important location factor for office firms.

Table 5.3 Regression results on office prices

	1987		1989		1991	
	coef.	stand. error	coef.	stand. error	coef.	stand. error
constant	245.27	51.16	231.35	41.14	299.16	58.80
orbital motorway	-17.27	10.72	-10.49	6.53	-23.21	9.15
railway station	0.43	11.87	3.23	5.32	-0.19	10.18
metro stops	1.81	10.60	-4.09	4.34	8.62	6.96
dummy variables						
South	7.64	31.37	57.87	15.55	63.26	23.25
Buitenveldert	7.87	38.00	43.07	22.74	-1.81	26.25
Amstelveen	46.23	46.96	54.99	23.95	68.37	32.02
South-east	53.80	29.94	25.51	18.39	6.52	33.29
Diemen	16.66	29.54	-12.63	19.41	-58.52	33.81
West	-46.08	56.43	-18.86	22.91	-92.76	32.04
East	-21.01	30.73	-5.85	20.21	-45.23	29.76
New buildings	24.12	12.77	31.55	8.49	36.86	12.77
R^2		0.27		0.46		0.44

6. *The Effects of the Orbital Motorway by Entrepreneurs*

6.1 Introduction

In spring 1992 a questionnaire was sent to 516 entrepreneurs - with a labour force of at least 10 persons - divided over three types of zones. The first zone consists of areas which are located near parts of the orbital motorway which already existed before the completion. The second zone consists of areas which became accessible after the opening of new segments of the orbital motorway. The third zone consists of areas which are located rather at a distance from the orbital motorway (either the inner city or the remote suburbs). The first zone is further on named the old accessible zone, the second zone the new accessible zone and the third zone the remote zone.

The questionnaire was sent to entrepreneurs in four economic sectors: industry, distribution, services and the office sector. The first two sectors have a strong orientation on the transport of goods, the latter on business and commuting traffic.

The net response of 25 % was evenly spread over the zones, but in favour of the office sector (48 %). In the old accessible and remote zone the office sector is the dominant sector with shares of 74 and 59 % respectively. In the new accessible zone the industry sector (41 %) and distribution sector (30 %) are the main economic sectors. These shares are close to the overall sectoral composition in those zones. Results will be presented for the whole agglomeration as well as divided at the zonal or sectoral level. At the disaggregate level of sectors within zones we will only present results for the dominant sector(s).

6.2 The use of the Amsterdam orbital motorway

The first part of the questionnaire deals with the actual use of the orbital motorway. In seems that all 44 companies in the old accessible, 44 out of 45 companies in the new accessible and 30 out of 41 companies in the remote zone

make use of the orbital motorway. The least use of the orbital motorway is made by the service sector in the remote zone. An explanation might be that those companies are oriented at the local market and thus make no use of the orbital motorway which is at some distance. A second argument concerns the activities of the service sector in general. The service sector generates traffic in the form of customers instead of own traffic.

Table 6.1 shows that the use of the orbital motorways for all traffic activities distinguished is high, especially for commuting and contacts with customers.

At the zonal level (A) the scores of the new accessible zone is above the average use for all activities except commuting. The scores of the remote zone are below average for all traffic activities. The scores of the old accessible zone are more diverse: above average for commuting and contacts with customers and below average for the delivery of goods.

At the sectoral level (B) some interesting things become clear. The relatively low use of the orbital motorway for the delivery of goods is explained by the low scores of the office sector for these activities, which is the dominant sector in our sample. All other sectors score above average for the delivery of goods.

Interesting is the fact that the service sector shows higher use of the motorway for the inflow of goods than the industry sector. On the other hand the industry sector shows relatively high use of the motorway for contacts with customers and business trips. The scores are even higher than the scores of the office sector for those activities. However, one has to bear in mind that the percentage of companies who use the motorway for a certain activity gives no insight in the intensity of use of those companies. The intensity of use of the orbital motorway for contacts with customers of the service sector might be well above the intensity of the industry sector. Nevertheless, it is quite reasonable to assume that the entrepreneurs unconsciously compensated their scores for the use by the intensity of use. We conclude that the scores of the sectors for the use of the orbital motorway for the activities distinguished are fairly robust. For instance, the scores for the delivery of goods are low for the office sector and the service sector scores low for visits to customers and business travel.

At the most disaggregate level (C) the high score in the new accessible zone for the delivery of goods is explained by the dominant position of the distribution and industry sector in this zone. The use of the motorway for these purposes is even above their sectoral average. The industry sector causes the high use for business travel and the distribution sector the high use for visits of customers. Both sectors show a low use of the orbital motorway for commuting. In the old accessible and the remote zone the office sector is dominant. This means a low use of the orbital motorway for the delivery of goods. The use of the motorway for visits by customers, business travel and commuting in the old accessible zone is substantially higher compared with in the remote zone. These differences explain the lower use of the orbital motorway in the remote zone compared with the old accessible zone.

Table 6.1 The importance of the orbital motorway for several transport activities (in %)

A. ZONAL	All respondents			New accessible		
	Imp.	Neutral	Unimp.	Imp.	Neutral	Unimp.
inflow of goods	60	9	31	81	5	14
outflow of goods	58	8	34	80	3	18
visits by customers	72	16	12	74	19	7
visits to customers	71	13	16	74	14	12
business trips	66	18	16	67	19	14
commuting	78	12	10	72	14	14
	Old accessible			Remote		
	Imp.	Neutral	Unimp.	Imp.	Neutral	Unimp.
inflow of goods	47	10	43	38	14	48
outflow of goods	41	14	45	38	10	52
visits by customers	83	5	12	50	31	19
visits to customers	73	11	16	63	15	22
business trips	67	19	14	59	15	26
commuting	88	12	0	73	10	17

B. SECTORAL	Industry			Distribution		
	Imp.	Neutral	Unimp.	Imp.	Neutral	Unimp.
inflow of goods	68	16	16	89	5	5
outflow of goods	75	13	13	84	11	5
visits by customers	76	20	4	78	11	11
visits to customers	88	13	0	75	10	15
business trips	88	8	4	60	35	5
commuting	72	12	16	76	10	14
	Offices			Services		
	Imp.	Neutral	Unimp.	Imp.	Neutral	Unimp.
inflow of goods	26	6	69	92	8	0
outflow of goods	26	6	69	70	0	30
visits by customers	68	16	16	67	20	13
visits to customers	71	13	17	33	17	50
business trips	66	16	18	36	21	43
commuting	85	12	4	67	20	13

C. ZONAL/SECTORAL	New accessible - Industry			New accessible - Distribution		
	Imp.	Neutral	Unimp.	Imp.	Neutral	Unimp.
inflow of goods	71	12	18	100	0	0
outflow of goods	81	6	13	100	0	0
visits by customers	71	24	6	77	15	8
visits to customers	82	18	0	77	8	15
business trips	88	13	0	54	38	8
commuting	76	18	18	69	15	15
	Old accessible - Offices			Remote - offices		
	Imp.	Neutral	Unimp.	Imp.	Neutral	Unimp.
inflow of goods	36	9	55	10	0	90
outflow of goods	36	9	55	10	0	90
visits by customers	77	7	17	44	38	19
visits to customers	68	14	18	69	13	19
business trips	70	17	13	50	19	31
commuting	90	10	0	76	18	18

6.3 *Hindrance before the opening*

When asked about the hindrance that companies have experienced over two third of the companies had complaints about the use of the infrastructure network before the opening of the motorway in 1990. The complaints were highest in the new accessible zone (which was not accessible by motorway before the opening) and by the distribution sector.

In Table 6.2 the scores for different kinds of hindrance are given. At the zonal level (A) the fact that the new accessible zone scores below the average except for the lack in punctuality of deliveries is interesting. It seems that the companies incorporated the expected delays in their behaviour. This is something which cannot be said for the companies in the old accessible zone. They give very high scores for time delay, late arrival of personel and staff and the lack of punctuality at appointments. The remote zone also gives a high score for delays in travel time.

Table 6.2 Hindrance before the opening of the orbital motorway (in %)

A. ZONAL	Total	New accessible	Old accessible	Remote
delay in travel time	90	79	100	94
detour	58	59	56	59
lack of punctuality at appointments	50	44	56	53
personel to late at work	46	35	67	35
lack of punctuality at deliveries	27	35	22	18
staff to late at work	14	6	26	12

B. SECTORAL	Industry	Distribution	Offices	Services
delay in travel time	88	76	97	90
detour	59	65	56	40
lack of punctuality at appointments	29	65	56	30
personel to late at work	29	41	59	40
lack of punctuality at deliveries	24	47	9	60
staff to late at work	0	18	25	0

C. ZONAL/SECTORAL	New accessible		Old Accessible	Remote
	Industry	Distribution	Offices	Offices
delay in travel time	87	70	100	100
detour	60	60	55	56
lack of punctuality at appointments	27	70	55	56
personel to late at work	27	30	70	33
lack of punctuality at deliveries	27	50	15	0
staff to late at work	0	10	25	22

At the sectoral level (B) it seems strange that the office sector scores higher for time delay then the distribution sector. However, the transport activities of the office sector concern mainly commuting which is within the peak hours. The activities of the distribution sector are more evenly spread over the day. In addition the distribution sector makes more detours to avoid congestion spots. The concentration of activities of the office sector in the rush hours also explains the relative high scores for late arrivals of staff and personel. The lack of punctuality of deliveries has serious consequences for the productivity of the distribution and industry sector.

The scores of sectors within the zones (C) are quite comparable with the score for the respective zone or sector. The sectoral composition of the zones reflect the kind of hindrace emerged in those zones as a consequence of the incomplete orbital motorway.
Only 40 % of the companies took measures to relieve the hindrance. Most measures were taken in the new accessible zone and by the industry sector. Least measures were taken in the old accessible zone. Over two third of the measures concern adjustments in route planning, working hours or a combination of both.

6.4 The effects of the opening for the companies

Most companies stated that the opening of the orbital motorway relieved the traffic problems for their company (Table 6.3). A clear majority noticed a reduction in travel time, a better accessibility and/or a decrease in annoyance participating the traffic. Although the effect reported by the majority is neutral, still a substantial percentage of companies noticed a rise in turnover, a decrease in the costs per unit product and/or improved punctuality in the delivery of goods.
At the zonal level (A) only a few differences on this general pattern occur. As before the major contrasts are between the new and the old accessible zone.
For instance, in the new accessible zone 64 % of the companies noticed a rise in the punctuality in the delivery of goods, whereas in the old accessible zone 74 % noticed no difference at all.
At the sectoral level (B) it is important to note that a relatively high percentage of companies in the industry and distribution sector experienced a decrease in the costs per unit product. Those sectors are - more than the other sectors - used to work in terms of costs per unit product and actually could notice changes in the costs structure of their products. Relatively many companies in those sectors also noticed an improvement in the punctuality of the delivery of goods. On the other hand a relatively high number of companies experienced an decrease in punctuality. The fact that the office sector is not used to work with physical products, leads to very neutral scores for changes in costs per unit product and in the delivery of goods.
The developments in the service sector are interesting. The relatively high score for the rise in turnover could point to a beter accessibility what could have resulted in a rise in the number of customers. Second, the strong reduction in travel time has led to an expansion of the market area. So not only the accessibility has improved but also the reach. And third, the rise in punctuality in the delivery of goods has led to more efficient operations.
At the most disaggregate level (C) it seems that the scores of the industry and distribution sector in the new accessible zone are more in accordance with the sectoral scores than the zonal scores. The percentage of companies who experienced a rise in accessibility or in punctuality in the delivery of goods in the industry sector is considerably below the zonal average. This is compensated by the high scores of the distribution sector on those fields.

Table 6.3 Effects of the orbital motorway (in %)

A. ZONAL	All respondents			New accessible		
	improved	neutral	worsened	improved	neutral	worsened
accessibility	80	19	2	91	10	0
travel time	76	14	10	76	12	12
annoyance in traffic	75	20	5	74	19	7
inflow/outflow of goods	43	50	7	64	28	8
costs per unit product	19	78	3	23	71	6
turnover	12	87	1	15	85	0
	Old accessible			Remote		
	improved	neutral	worsened	improved	neutral	worsened
accessibility	74	24	2	72	24	3
travel time	71	21	7	83	7	10
annoyance in traffic	78	20	3	72	21	7
inflow/outflow of goods	24	74	3	35	52	13
costs per unit product	9	89	3	28	72	0
turnover	16	82	3	4	96	0

B. SECTORAL	Industry			Distribution		
	improved	neutral	worsened	improved	neutral	worsened
accessibility	80	20	0	84	16	0
travel time	80	12	8	80	10	10
annoyance in traffic	73	23	4	74	11	16
inflow/outflow of goods	50	38	13	65	18	18
costs per unit product	32	68	0	31	63	6
turnover	10	86	5	18	82	0
	Offices			Services		
	improved	neutral	worsened	improved	neutral	worsened
accessibility	75	22	4	87	13	0
travel time	76	18	6	64	14	21
annoyance in traffic	79	21	0	75	17	8
inflow/outflow of goods	24	74	2	60	40	0
costs per unit product	9	86	5	9	91	0
turnover	9	91	0	27	73	0

C. ZONAL/SECTORAL	New accessible - Industry			New accessible - Distribution		
	improved	neutral	worsened	improved	neutral	worsened
accessibility	82	18	0	92	8	0
travel time	78	17	6	83	0	17
annoyance in traffic	78	22	0	75	8	17
inflow/outflow of goods	53	35	12	82	9	9
costs per unit product	33	67	0	20	70	10
turnover	7	93	0	20	80	0
	Old accessible - Offices			Remote - offices		
	improved	neutral	worsened	improved	neutral	worsened
accessibility	70	27	3	79	16	5
travel time	70	27	3	88	6	6
annoyance in traffic	81	19	0	76	24	0
inflow/outflow of goods	23	77	0	17	75	8
costs per unit product	8	88	4	14	86	0
turnover	14	86	0	0	100	0

6.5 Expected consequences if the orbital motorway had not been completed

In Table 6.4 the results are given of questions about the effects which would have occurred in case the orbital motorway had not been completed. As shown, this would especially have had effects on the investments of the companies. About 10 % stated that they would have invested less. A minor number of companies expected to have less personel or stated that they would have moved to another location. These negative effects would have been felt hardest in the new accessible zone and in the office or distribution sector.

Table 6.4 Expected effects if the orbital motorway had not been completed

A. ZONAL	Total	New Accessible	Old accessible	Remote
firm closed	1	-	1	-
firm smaller	4	1	1	2
firm relocated	7	2	3	2
less invested	11	8	2	1
less personel	6	4	0	2
Number of questionnaires	130	45	44	41

B. SECTORAL	Total	Industry	Distribution	Offices	Services
firm closed	1	-	-	1	-
firm smaller	4	-	1	3	-
firm relocated	7	-	1	6	-
less invested	11	2	4	4	1
less personel	6	-	2	3	1
Number of questionnaires	126	26	22	60	18

7. Conclusions

The completion of the Amsterdam orbital motorway has had substantial impacts on the choice of routing and timing of trips. The impact on modal choice and trip frequencies have been small. Time losses due to congestion in the Amsterdam area have been reduced with about 20 %.

There are no indications that office prices in zones directly benefitting from the completion of the orbital motorway increased more strongly than in other zones. On the contrary, office prices at locations near already existing parts of the orbital motorway displayed the largest increase after the completion. Thus, the ringroad seems to have reinforced the position of zones which already had a strong competitive position in the region.

A statistical analysis of office rents reveals that distance to the nearest orbital motorway ramp has a significant negative impact on office prices. For the railway and metro system no such effects are found.

In a survey among entrepreneurs some 60 - 70 % indicated that the orbital motorway is important for transport activities such as inflow and outflow of goods, visits of customers and commuting. Before the motorway was completed firms experienced hindrance in the form of delays (90 %), lack of punctuality at appointments (50 %) and personel arriving too late (40 %). According to about

80 % of the respondents the completion of the ringroad led to an improvement of accessibility. Some 10 - 20 % of the firms indicated that they experienced an increase in turnover and/or productivity as a consequence of this. Almost 10 % of the firms indicate that they would have invested less had the ringroad not been completed.

References:

- Bonsall, P.W. (1992), Feasibility of Measuring Responses to Highway Improvement, Institute of Transport Studies, Leeds.
- Bruinsma, F.R. & P. Rietveld (1992), De Structurerende Werking van Infrastructuur: een State of the Art Review, Projectbureau IVVS, Den Haag.
- Bruinsma, F.R., G. Pepping & P. Rietveld (1993), Economische Uitstraling Opening Ringweg Amsterdam, Rijkswaterstaat, Rotterdam.
- Dasgupta, M., & V. Webster (1992), Land Use/Transport Interactions: Policy Relevance of the ISGLUTI Study, paper presented at the World Conference in Transportation Research, Lyon.
- Guiliano, G. (1986), Land Use Impacts of Transportation Investments: Highway and Transit, in: S. Hanson (ed.), The Geography of Urban Transportation, The Guildford Press, New York, pp. 247-279.
- Hall, P. (1990), Keynote Address on Orbital Motorways, in: D. Bayliss (ed.), Orbital Motorways, Thomas Telford, London, pp. 1-31.
- Lathrop, G.T. & K.E.Cook (1990), The Effects of Beltways on Urban Development: a Discussion of US Experience, in: D. Bayliss (ed.), Orbital Motorways, Thomas Telford, London, pp. 143-156.
- Linneker, B.J., & N.A. Spence (1992), An Accessibility Analysis of the Impact of the M25 London Orbital Motorway on Britain, Regional Studies, Vol. 26, pp. 31-47.
- Rietveld, P., Spatial Impacts of Transport Infrastructure Supply, Faculty of Economics, Vrije Universiteit, Amsterdam, 1993.
- Rijkswaterstaat (1992), Effects of the Opening of the Amsterdam Orbital Motorway: Final Report Phase 1, Transportation and Traffic Research Devision, Rijkswaterstaat, Rotterdam.
- Webster, F.V., P.H. Bly, & N.J. Paulley (eds.) (1988), Urban Land-Use and Transport Interaction: Policies and Models, Avebury, Aldershot.

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