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Bruinsma, F.R.; Rienstra, S.A.

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Frank R. Bruinsma
Sytze A. Rienstra
Piet Rietveld

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Frank R. Bruinsma
Sytze A. Rienstra
Piet Rietveld

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Department of Regional Economics
Free University
De Boelelaan 1105
1081 HV Amsterdam
The Netherlands

Introduction

Low levels of transport infrastructure investments in the 1980's in most industrialized countries have stimulated discussions about the need to increase investment levels in the 1990's. In addition to environmental aspects that have become increasingly important in such discussions recently also the economic aspects have received much attention here.

Basically three approaches can be distinguished in the discussion about the economic impact of transport infrastructure. The first approach is the well known social cost benefit analysis (CBA) with consumer surplus as the main object. This approach is firmly based on efficiency objectives in welfare economics and has been widely used in various countries.

More recently a second approach has emerged where consumer surplus is no longer the basic concept, but productivitv (cf. Aschauer 1989). Implicit in this approach seems to be that CBA is sometimes regarded too broad because its outcome may strongly depend on travel time savings of households which do not have implications for GDP. On the other hand CBA outcomes are sometimes regarded as too narrow because in the calculations of the benefit the strategic long term macro economic benefits in terms of GDP are only partially taken into account.

The third approach even moves further away from CBA by focusing on employment. This happens especially in countries with high levels of structural unemployment where job creation is considered of prime interest. In this approach the spatial dimension is often relevant: transport infrastructure investments have spatially differentiated impacts on employment.

Of course, the three approaches are not entirely independent; they are partially overlapping, partially conflicting , and partially complementary .

In the present paper we will not go into these interrelationships, but mainly contribute to the third approach by focusing on employment aspects of transport infrastructure; in addition some attention will be paid to the second approach.

After a brief discussion in which the relationship between transport infrastruc-

ture and spatial patterns of economic activities is sketched from a theoretical perspective (section 2), the focus of the article shall shift to some methodological issues (section 3). As will be shown, a variety of approaches at different spatial levels of aggregation have been applied in research in this field. The results obtained with those approaches are rather diffuse. In sections 4-6 the empirical results are presented of a study on economic impacts of the construction of the transnational Al highway on Dutch regions. In this study various methods have been used at various levels of spatial detail.

2 Theoretical framework

In Figure 1 the complex relationship between transport infrastructure and regional economic development is presented (Bruinsma 1994). The construction of transport infrastructure influences the transport costs by means of a reduction of distances and/or a higher average speed (relation 1). This will lead to changes in the choice of transport mode, route choice, time of departure (in case of congested networks) and the generation or attraction of new movements per zone (relation 2).

The reduction in transport costs combined with the changes in the patterns of movements of households and firms will lead to an increase in the productivity of the zones involved (relation 3 and 4). Another consequence is an increase of the accessibility (relation 5). The accessibility of a zone depends on all possible efforts necessary to visit or leave this zone.

The increase in productivity and accessibility in a certain zone may result in an expansion of the economic activities and/or population within the zone (relation 6 and 7).

Until now only direct links between the construction of transport infrastructure and the spatial pattem of economic activities are discussed. However, there are also a number of indirect - feedback - relations which are important.

A first feedback concerns the relocation of economic activities, which results in changes in the masses of the zones involved. This may again have its impact on

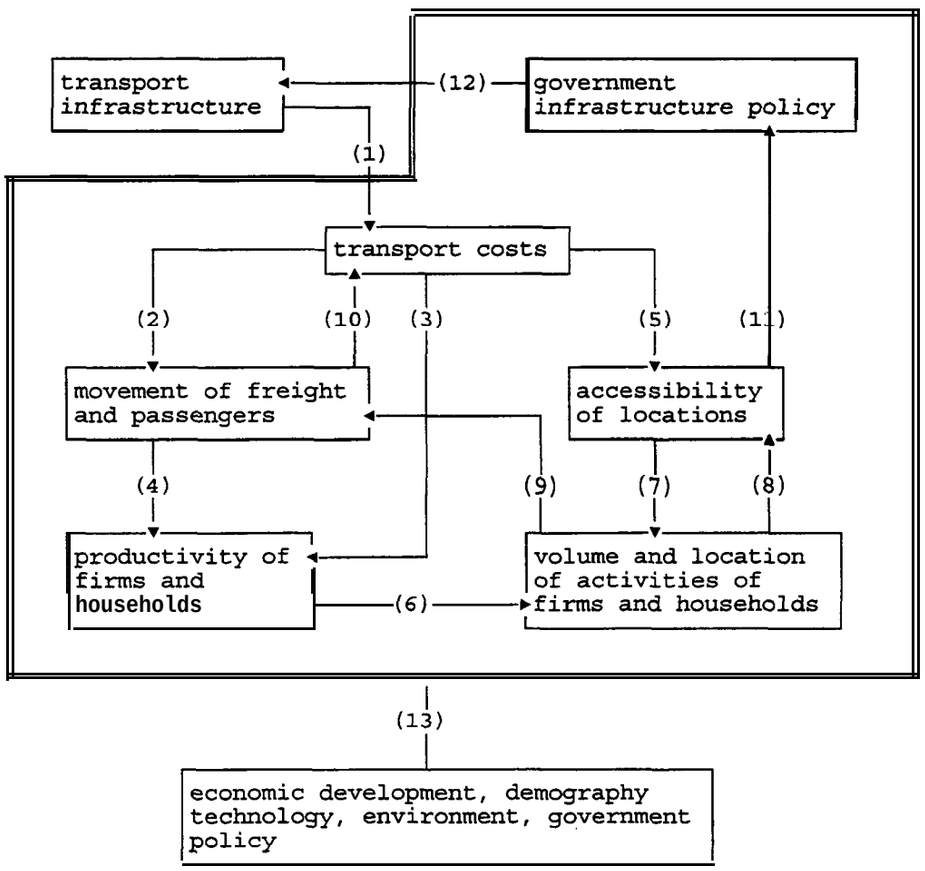

Figure 1 Conceptual model on the relation between transport infrastructure and the spatial pattern of economic activities

the accessibility of the zones (relation 8).

The changes in the location of economic activities influence the number of movements of freight and passengers in a similar way (relation 9). In case of congestion this shift in the number of movements of freight and passengers imply changes in transport costs too (relation 10).

Transport infrastructure cannot be seen as completely exogenous since it is developed by the government. The government reacts on changes in the transport system. The main target of government infrastructure policy may be to secure an acceptable level of accessibility for each zone (relation 11 and 12). On the other hand the economic policy might be oriented on the

development of additional transport infrastructure in zones with a relatively positive economic development, for instance to overcome congestion.

A last element in Figure 1 concerns the fact that not only new transport infrastructure has an important impact on the development of traffic flows and the spatial patterns of economic activities. In general, factors like technology, demography, economy, and environmental and public policy may be mentioned (relation 13). Those factors shape a wider context in which the relationship between transport infrastructure and the spatial pattern of economic activities has to been seen.

Thus we end up with a rather complex model with various feedbacks. As a result, the impacts of transport infrastructure improvement on the economy are not always easy to determine. This can also be understood from related theoretical frameworks. For example, interregional trade theory shows that a positive impact of a decrease of interregional transport costs on employment in a particular region is not guaranteed. A reduction of these costs leads to an increase of interregional competition. Local and regional production may be replaced by imports from competitive regions. The induced specialisation process may prove to be disadvantageous for employment in low productivity regions.

3 Empirical approaches

In this paragraph a concise summary is presented of approaches which are in common use in empirical research to trace the impact of new infrastructure on spatial patterns of economic activities. A diagram overview of approaches is given in Figure 2. The approaches applied later on in the empirical part of this article are printed in a bold way.

In Figure 2 a twofold subdivision is used. First, there is a subdivision between models and non-model approaches. Second, there is a subdivision based on the spatial level of aggregation of the data input. In order to emphasize the variety among these approaches we give below some short

	Models	Other approaches
Aggregate data	- transport land use models - production function models - location models - interregional trade models - genera1 equilibrium models	- quasi experimental
Disaggregate data	- stated preference models - revealed preference models	- quasi experimental - entrepreneur survey - expert judgement - calculation of the impact of infra-structure on transport costs

Figure 2 Examples of research methods used to study economic impacts of transport infra-structure investments

comments on their particular features. For a broader review refer to Vickerman (1991), Bruinsma (1994) and Rietveld (1994).

Models based on **aggregate data**

This type of models is mainly used by transport engineers, urban planners and economists.

Integrated transport-land use models for example have mainly been developed by urban planners and transport engineers. These models can be considered as an extension of the well known urban transport models where a feedback is formulated from the transport system on employment and population growth in the various zones. An overview of those models is presented in Webster et al. (1988).

Another example is the production function approach, which has become very popular among economists after the work of Aschauer (1989). In the production function approach the level of production depends on the classic private production factors - capital and labour - supplemented with a (transport) infrastructure variable. Production functions are applied to estimate the impact of an improvement of a certain type of transport infrastructure on the

productivity of labour and capital (see Biehl (1986) for an example at the European level).

Improvement of transport infrastructure in a region may lead to an increase in the productivity of private production factors as described above. This may lead to an expansion and/or relocation of those production factors in and between regions. This effect is analyzed by location models. In those models the impact of transport infrastructure is analyzed together with other factors that may influence the location of firms like the price of labour, investment subsidies, sectoral structure, accessibility of markets etcetera. The main target in a location model is to explain the changes in private investments and/or employment by those location factors (see for instance Evers et al. 1987).

Models based on disaggregate data

Revealed and stated preference approaches are most common for studying the impact of transport infrastructure on spatial patterns of economic activities with models using data on a disaggregate level. These approaches may be applied at different spatial levels.

Both approaches are based on individual utility functions. In the case of revealed preference models the utility function is estimated with data concerning choice behaviour in actual situations. In case of stated preference models the data concern preferred behaviour of respondents who made a choice in a laboratory situation.

Both methods have their strengths and their weaknesses as documented in the literature (Kroes and Sheldon 1988). Revealed and stated preference models have to be seen as complementary instead of opposite, since they provide complementary information and avoid the weaknesses of the other.

Other approaches based on aggregate data

The quasi-experimental approach is an example of a non-model approach based on aggregate data. In this approach the development in a region is

analyzed after an improvement of the infrastructure. This development is compared with the development in the region before the improvement and/or with a group of reference regions. The choice of appropriate reference regions is vital for the quality of this approach (Isserman 1990).

Other approaches based on disaggregate data

One of the non-model approaches that is commonly used among geographers concerns surveys among entrepreneurs. Those surveys may be postal questionnaires, telephone or face to face interviews. These surveys allow one to receive information from entrepreneurs about various subjective elements, including perceptions and expectations. These aspects are certainly relevant for this type of research but are usually ignored in model type studies.

This short survey of research approaches reveals that widely different methods are used to address the issue of transport infrastructure impacts on the economy. These methods differ among others in theoretical background, type of data used, spatial level of analysis and dependent variable (productivity versus employment). It is therefore not surprising that these approaches sometimes lead to rather different outcomes (see Offner 1992). Therefore it is recommended that in studies on this subject various approaches are used. An example of such a multi-method approach is presented in the next sections.

4 A case study: the construction of the Al highway

4.1 The Al transport corridor

The highway network in the Netherlands has mainly been constructed in the last thirty years. During the same period a strong increase of the mobility level and the traffic intensity on the network occurred. Nowadays the Netherlands are covered by a highway network, which is in Europe only

exceeded by the Belgian network in density.

In such an extensive network a new link will usually only have limited impact for the network in total, so that the expected spatial economic impacts will be small. An exception of this may be transnational links. Using a European perspective Bruinsma en Rietveld (1994) showed for example that such links are relatively scarce in most networks. An example in the Netherlands of a transnational corridor that was created only recently is the Al highway. This highway connects the relatively badly accessible eastern part of the country with the national and international road network. The Al highway runs from Amsterdam, via Amersfoort, Apeldoorn, Hengelo and Oldenzaal to the German border (Figure 3). It is one of the most important east-west axes in the Dutch road network and provides also a main connection to the German road network. In Germany this highway runs as E8 to Berlin and Poland. It is also one of the main routes towards the Scandinavian countries.

The construction of the Al from Amsterdam up to Twente took place between 1970 and 1975. Then the construction stopped to a large extent: the section up to Hengelo was opened in 1979, the remaining sections up to the German border were constructed in small sections between 1985 and 1992. Almost all these sections have been constructed as entirely new links, only the section Oldenzaal-German border is an upgrading of the existing road .

4.2 The research area

The Al highway crosses three Corop regions between Apeldoorn and the German border: the Veluwe, Southwest-Overijssel and Twente (Figure 3). The Corop region is a statistical unit between the level of provinces and municipalities. To analyze the impacts of the highway construction it is important to know something about the economic development of the area. The analysis will be limited to the period 1970-1990, because the Al construction took place in this period.

After 1970 a recession occurred in the Western world and also in the

Figure 3 Research area

Netherlands. In the **second** half of the 1980's **however**, a strong recovery manifested itself. In the observed period **also** structural **changes** took place in the **sectoral structure** of the economy. During the period considered, the share in employment of the industry sector in the Dutch economy decreased from 42 until 29 **%**, while the share of the services sectors increased from 42 until more than 54 %.

In spatial terms a deconcentration **process** took place. The **economic**

development of the Randstad area (see Figure 3) was slightly below the national average. The so-called intermediary zone developed favourably, while the peripheral zone experienced a less positive development. The intermediary zone is defined by the area between the central Randstad regions and the peripheral regions in the Netherlands (Figure 3). The research area chosen is located in the intermediary zone which experienced - with maybe the Twente region as an exception - a relatively favourable economic development.

In order to correct for sectoral composition effects in the growth of employment one might use shift-share analysis (Armstrong and Taylor, 1993). A differential shift in a region of for example 10 % means that - after correction for the sectoral structure - the employment growth is 10 % higher than the national average. In this way the growth rate is corrected for advantages and disadvantages which may occur because of the initial sectoral structure. The differential shifts of the Al-regions are presented in Table 1.

It appears that the Veluwe had the most favourable economic development, while the differential shifts of Twente appear to be less favourable. The high shifts in the Veluwe are mainly explained by the rapid growth of service sector in this region, where in the period 1970-1975 especially defence employment grew rapidly. The economy of Southwest-Overijssel on the other hand has a high share of the industry sector, while the service sector is relatively small. In the analyzed period one can clearly observe a convergence of the regional production structure in these two regions towards the national average. This does not hold true for Twente to the same extent.

Table 1 Differential shift of employment in the Al-regions (corrected by sectoral structure)

	'70-'75	'75-'80	'80-'85	'85'90
Veluwe	0.10	-0.00	0.02	0.05
Southwest-Overijssel	0.01	0.02	-0.02	0.08
Twente	0.03	0.02	-0.02	0.02

This region has traditionally been oriented on the industry (mainly metal and textile). The employment in the textile industry decreased rapidly because of many reorganizations. When the figures are corrected for the sectoral structure however, also Twente appears to have a positive differential shift in most periods.

5 Analysis at the regional level

At the Corop level two research methods have been applied. In the first place a reference region method (quasi experimental approach) has been used. In this method the employment growth in AI regions has been compared with that of reference regions. These are comparable with the AI regions in terms of economic structure and location, but in these regions little or no construction of main road infrastructure took place. Next, a regional labour market model has been constructed in which accessibility - via the main road network - is one of the main variables.

5.1 The reference region method

The first approach at the regional Corop level is the reference region method. First the development of regional employment will be compared with that in the remainder of the intermediary zone (see Figure 3). Next the distinct regions will be compared with specific reference regions, which are also located within this zone (for a more detailed analysis we refer to Bruinsma et al. 1995a).

In Table 2 a comparison is made between the differential shift in the three AI regions and the remainder of the intermediary zone and the distinct reference regions.

When we compare the differential shifts in the periods of opening of the AI, we find that in the Veluwe the shift is much higher than in the intermediary zone. At first sight this seems to be the result of the AI construction. When

Table 2 Differential shift in the intermediary zone, the AI regions and the reference regions (corrected by sectoral structure)

	'70-'75	'75-'80	'80-'85	'85-'90
Intermediary zone	0.05	0.01	0.02	0.04
Veluwe	0.10	-0.00	0.02	0.05
reference region: Achterhoek	*0.05*	0.05	-0.04	0.07
Southwest-Overijssel	0.01	0.02	-0.02	0.08
reference region: NE-North-Brabant	*0.70*	0.03	0.05	0.10
Middle-Limburg	*0.11*	*0.09*	0.02	0.06
Twente	0.03	0.02	-0.02	0.02
reference region: Aggl. Arnhem/Nijmegen	*-0.00*	-0.02	-0.03	0.01
SE-North-Brabant	0.03	-0.00	0.02	0.06

periods in which the AI is constructed are printed fat

the sectoral structure is investigated however, it appears that the high differential shift is mainly caused by growth of the government sector, in the form of a growth of defence employment. It is not likely that this employment has been attracted by the construction of the AI.

When we inspect the other periods during which construction took place, we observe that the differential shift in Twente is somewhat higher in the period 1975-1980. In the other relevant periods the shift is *lower* than in the intermediary zone, however. Also an investigation of lagged effects does not lead to clear results on an impact of highway construction on regional employment growth. So it is concluded that a positive influence of the construction of the AI on the shift cannot be proven by using the remainder of the intermediary zone as reference region.

Although it is certainly relevant to compare the development of the AI regions with that in the intermediary zone, it is clear that the intermediary zone is not an entirely satisfactory reference region. The reason is that in the periods concerned, also other highway construction projects took place in the intermediary zone. Therefore a more detailed analysis with reference regions which did not experience extensive highway construction projects

during the periods concerned has been carried out too (Table 2, Figure 3). It appears that in 8 cases an AI region has a higher differential shift than the reference region during a period of AI construction. In one case the shifts were equal, while the shift is lower in 11 cases. About the same figures are found when a one period lag is assumed.

It may be clear that the results in this approach depend strongly on the reference regions chosen. It appears however, that also when other relevant reference regions are chosen, the conclusion remains about the same. A problem is that this approach is rather crude, because no other specific features of the regions are taken into account, as is the case with the model approach. Clearly, in a relatively small country with only 40 statistical Corop regions, one cannot select reference regions in such a way that they satisfy all requirements for a quasi-experimental method (cf. Isserman 1990). Therefore, a multivariate approach is recommended as a complement to the reference region method. This is the subject of the next section.

5.2 The regional labour market model

A second approach at the regional Corop level is to use a regional labour market model. In the final estimation of the regional labour market model at the Corop level the differential shift in employment of a region during a five year period is explained by:

acc	the relative change in domestic accessibility
int	the relative change in international accessibility
unemp	the relative change in short term unemployment
educ	the relative change in the level of education
urb	the level of urbanization
pol	the regional policy variable (a dummy)

The results of these estimations are presented in Table 3; the coefficients which are significant at a 5 % level are marked with an asterisk.

It appears that the change in domestic accessibility had a significantly negative impact on the employment in the period 1970-1975, while in the period 1985-

Table 3 Results regression analysis for the differential shift in employment

	1970-1975 coefficient	1975-1980 coefficient	1980-1985 coefficient	1985-1990 coefficient
acc	-0.94'	0.74	0.22	2.12'
int	0.08	0.20	1.47	-0.67
unemp	-0.01	0.22'	0.05'	0.15
educ	-0.54'	-0.09	0.03	-0.07
urb	-0.65'	-0.15	-0.19'	-0.28'
pol	-0.10'	-0.04	-0.06'	-0.07'
constant	0.51'	-0.02	0.02	0.00
R^2	0.52	0.59	0.50	0.26

1990 this impact was positive. In the other periods no significant impact is found. The intemational accessibility - made operational by the accessibility to the main German and Belgian cities - does not have a significant impact on regional employment. Thus, a clear impact of a change in accessibility on the shift in regional employment cannot be proven.

Of the other variables the change in unemployment rate has a positive sign in two five-year periods: employment growth is higher in regions with a large increase in labour surplus. The leve1 of education does not have the expected impact. The urbanization density has a significantly negative sign in three periods, which means that the urban-rural manufacturing shift (see Keeble et al. 1983) has a stronger influence than agglomeration advantages. The regional policy has a negative significant sign in three periods, which may mean, that the substitution effect of capital subsidies on employment is larger than the output effect. Another possible interpretation is that the regions receiving govemment support are regions with structural weaknesses, not incorporated by the other variables. Govemment policies are not strong enough to overcome these structural weaknesses and as a consequence a negative sign is found for the policy variable.

A sector where a significant impact of a change in accessibility on employment

growth may *be* expected is the *transport and commnication sector.* Regression results for this sector are reported in Bruinsma et al. (1995a); it appears that the domestic accessibility has a significant positive influence on the employment in this sector in the three periods between 1975 and 1990. The same accounts for the intemational accessibility in the periods 1970-1975 and 1985-1990. So it may concluded that the change in accessibility has a positive impact on the development of employment in the transport sector. The other variables give about the same results as the model for the total employment.

As far as the other economic sectors are concemed the domestic as well as the intemational accessibility do only have in a smal1 number of cases a significant influence on employment growth. In an alternative specification we tested whether the accessibility variable has a different impact for importing and exporting sectors, but this did not yield better results for the individual sector estimates. The conclusion is that the transport and communication sector is the only one where a consistent impact of highway construction during several periods can be demonstrated at the Corop level.

5.3 Conclusions

By using the reference region approach and the regional labour market model we could demonstrate a significant impact of highway construction on employment growth in the transport sector. For the other sectors and for aggregate employment growth no significant results were obtained.

A reason for this negative result may be that the density of the network is already relatively high. In the case of the Al however this argument does not apply . In the first place the highway is entirely new and not an upgrading of an existing road. Second, there is no altemative connection at the highway leve1 available from and to the regions connected by the Al ; in addition the completion of the Al implies a high quality connection to the German road network. All other highways are located rather far from the research area.

A possible explanation of these results is that the spatial scale leve1 of Corop regions may be too high for our purpose. It is not impossible that at lower

spatial levels such impacts may be found. This will be discussed in the remainder of this article.

6. A survey among entrepreneurs

In the last week of April 1994 1.845 questionnaires have been sent to firms in the provinces of Overijssel and Gelderland with at least 10 employees. Only firms in sectors with a predominantly non-local orientation of demand have been included. The net response is 510 questionnaires (27.6%), which are representative for the target population according to location, sectoral composition and size (for a more detailed analysis we refer to Bruinsma et al. 1995b).

It may be argued that infrastructure does not only have objective effects (e.g., via transport costs), but that also subjective effects (e.g. status considerations) are important. Some of the answers of respondents on the importance of infrastructure will reflect both objective and subjective effects. In order to avoid the risk that respondents would perceive the questionnaire only from an infrastructure perspective, which might lead to biased results, in the questionnaire ample attention was paid to the broader context in which firms operate, as well as to firm internal factors.

6.1 Infrastructure and firm development

Development of employment

The employment growth of the firms which responded was 52 % in the period 1980-1994, which is a very high growth rate. This can be explained by the fact that the companies selected have survived the recession period, or are starters in this period; so no questionnaires have been sent to companies which became a bankrupt, and to companies of which the number of employees fell under 10 employees. The industry sector, which accounts for most employment (48 %), grew relatively slowly (27 %) during the period considered.

Most employment in the study area (65 %) appears to be located within 5

kilometres of an access of a highway. Also the main population centres and largest firms are found in this area, so this is not a striking fmding.

Market perspectives and intemal company considerations appear to be the main factors influencing employment growth (Table 4). In a previous research project in 1989 (Bruinsma et al. 1992) similar results were found for the Twente region. Other factors that are often mentioned as 'very' important are: availability of employees, accessibility by Al, accessibility by road, parking possibilities, expansion possibilities of buildings, representativeness of the location and the price of the location. A closer look at these factors reveals that infrastructure related factors (accessibility by road, accessibility by Al) are only considered as 'most' or 'second most' important in a smal1 number of cases (this also holds

Table 4 Perceived impact of (location) factors on employment growth and locational decisions (in %)

	growth emolovees			decision to relocate the firm				
					push factors		pull factors	
	1	2	3	1	2	3	2	3
internal company considerations	24,0	19,6	22,8	24,8	9,2	7,4	7,4	2,5
market perspectives	53,3	65,0	18,8	27,0	2,0	9,6	3,4	3,3
education employees	6,6	1,8	4,8	0,9	0	0	0	0
availability employees	12,7	2,4	13,2	4,7	0	1,1	0	0,8
telecommunication	8,8	0,2	1,1	5,7	0	2,1	0	0,8
accessibility by Al	12,9	0,7	2,2	17,8	2,0	1,1	8,1	3,3
accessibility by road	10,9	1,3	5,9	21,6	7,8	12,8	13,4	9,9
public traffic	3,5	0	0	5,6	0	0	0	0,8
parking possibilities	10,1	0	0,3	16,2	0,7	9,6	1,3	1,7
govemment	6,3	0,2	1,4	4,6	0,7	2,1	0,7	0
image region	8,1	0,2	2,2	17,9	0	0	0,7	4,1
expansion possibilities of buildmgs	25,6	6,2	13,5	54,3	61,4	16,0	45,0	19,0
representativeness location	16,6	0,7	2,2	46,6	4,6	25,5	8,7	31,4
price location	14,2	0,2	1,7	26,0	1,3	3,2	5,4	13,6
subsidies	7,6	0,4	2,0	15,5	0	0	2,7	5,0
residential environment	7,5	0,2	2,2	14,4	7,8	6,4	2,7	0,8
private factors	8,3	0,9	5,6	10,1	2,6	3,2	0	2,5

1 = percentage of entrepreneurs that value the factor 'very' important
2 = percentage of entrepreneurs that value the factor 'most' important
3 = percentage of entrepreneurs that value the factor 'second most' important

true for the price, and the representativeness of the location). Thus, although infrastructure is often very important in the eyes of the entrepreneurs, it is not so often 'most' or 'second most' important. Other factors are apparently more decisive when one wants to explain employment growth of individual firms.

New and relocated firms

Of the 510 firms surveyed, 100 started between 1980-1994, while 182 relocated during that period. Striking is that of the 100 newly started firms no less than 46 have relocated at least once in this period; obviously young (successful) firms are more mobile than other firms.

The service sector appears to be most dynamic; the percentage of starters as well as relocations is the highest for this sector. The industry sector on the other hand is least dynamic.

When the distance to a highway is analyzed, it appears that the rate of birth of new firms, and the rate of relocation of firms are higher in the zone until 7.5 kilometres of an access compared with zones further away . When the relocated firms are analyzed more in detail, it appears that 42 % stays in the same four digit postal code area, while 75 % stays in the same city or village. When the change in distance to a highway is measured 41 % of the firms appears to relocate towards a highway, while 16 % of the firms relocate to a site at a larger distance. The average relative change in distance to an access due to a relocation is a decrease of 28 %. Thus relocations of firms lead on average to shorter distances to highways. Another obvious reason why average distance to highways decreases is that new highways are constructed in the course of time.

As also shown in the 1989 study, market perspectives and intemal company considerations are not the main factors for a relocation decision; these are only found as next important factors, together with the price of buildings and location, the accessibility by road infrastructure in genera1 and - to a lesser extent - the Al (Table 4). The most important factors appear to be the expansion possibilities of buildings and the representativeness of the location.

When a distinction is made between push and pull factors it appears that the

most important push factors are the bad quality and expansion possibilities of buildings and to a lesser extent the bad accessibility by road, the residential enviromnent and a shortage of parking lots. On the other hand, the most important pull factors are the expansion capacity, the representativeness and to a lesser extent the price and the accessibility of the new location. An interesting conclusion that can be drawn from Table 4 is that road accessibility - and especially accessibility of the Al highway - is more important as a pull factor than as a push factor in location behaviour of firms. Only after entrepreneurs have decided to relocate, they start to attach a role of some importance to road accessibility .

6.2 Infrastructure components

In this section the importance of various infrastructure components will be discussed. First an analysis is presented of the infrastructure elements which are considered to be the most important by entrepreneurs. Next entrepreneurial perceptions on infrastructure bottlenecks are discussed. Finally the values given by entrepreneurs to the impacts of the Al construction on specific elements of the firms performance are discussed.

The impact of infrastructure in general

It appears that especially road infrastructure is valued often as 'most important' (Table 5). Telecommunication is found next, while public utilities are valued a little lower. It may be clear that all these elements are intensively used by all firms, while airports and railways are used much less; these are valued much lower, accordingly . As shown in the last column of Table 5 the changes in importance of infrastructure components during the past period are rather similar to the present importance, although certain shifts can be observed. Roads remain dominant but especially telecommunication and airports are relatively often mentioned as infrastructure components of increasing importance.

We als0 investigated to what extent the present location of firms has an impact on the valuation of the importance of infrastructure (Bruinsma et al., 1995b). It appears that there are no significant differences between the valuations accord-

Table 5 The importauce of infrastructure (in %)

	1	2	3	4
roads	76,2	79,4	9,1	66,4
rail roads	2,3	0,7	11,6	7,3
waterways	2,6	1,3	4,0	3,8
airports	5,2	0,4	4,5	17,0
telecommunication	39,3	3,6	29,5	62,1
public utilities	27,3	4,7	18,2	24,2
terminals	4,3	0,4	4,8	8,9
no opinion		9,4	18,2	
total		100	100	

1 = % entrepreneurs that value the infrastructure component 'very'importaut
2 = % entrepreneurs that value the infrastructure component 'most' important
3 = % entrepreneurs that value the infrastructure component 'second most' important
4 = % entrepreneurs that noticed an increased importance over the last five years

ing to distance to highways. This also holds true for the valuation of highways: entrepreneurs with firms located further from the Al did not value road infrastructure lower than entrepreneurs with firms nearby.

Bottlenecks in the infrastructure networks

Among the entrepreneurs 44 % mention that they suffer from bottlenecks in infrastructure networks, especially in road infrastructure and to a lesser extent in telecommunication. Conceming road infrastructure, bottlenecks at all spatial levels are mentioned. At the *national* leve1 especially congestion - mainly in the western part of the Netherlands (the Randstad) - is experienced as a bottleneck. Thus congestion in the most highly urbanized part of the country does not only disturb firms located there, but also firms in the more peripheral parts of the country. Striking is that bottlenecks in the *international* road network are only mentioned in 1 % of the cases; in particular the connection with the German Ruhr area is' mentioned. This may be considered - especially for a border region - very low. It is an indication that there is in this case no serious mismatch between supply and demand for infrastructure in border regions. A similar result was found by Bruinsma and Rietveld (1994) for a much broader set of

European border regions.

The valuation of the importance of infrastructure components does not only depend on the intensity of use, but also on bottlenecks experienced. This is the reason that road infrastructure and telecommunication figure prominently in Table 5. The low leve1 of bottlenecks in services of public utilities is an explanation why these receive lower scores in this table.

Impact of the Al on the performance of fii

In the questionnaire the entrepreneurs were asked to consider the case that the Al highway would *not* have been constructed. The impacts of the construction of the Al highway on firms are described in Table 6.

The impact is especially found in increased accessibility and shorter travel times and to a lesser extent in the punctuality of goods supply . These results are not very striking since the research area is not suffering from serious congestion. Striking however is, that the least positive impact is found for the size of the intemational market area. For a transnational transport corridor like the Al these fmdings are rather disappointing. The impact of the construction appears to be smaller when the company is located further away from the Al. This holds true for the impact on sales as well as on accessibility . The impact on travel time is especially smal1 when the site is located more than 7.5 kilometres away from the highway .

Table 6 Impacts of the Al construction on firms

	strong improvement	improvement	no impact	no opinion
accessibility	38.7	31.7	20.7	9.3
travel time	31.9	38.9	20.1	9.2
punctuality deliveries	13.2	33.0	38.8	15.0
sales	7.9	19.5	55.2	17.4
national market	9.8	19.6	54.4	16.2
export market	5.6	12.3	63.0	19.2
costs per unit	6.2	23.6	51.1	19.0

Table 7 Expected impacts if the Al was not constructed on firms

	agree	disagree	no opinion
company closed down	0.8	78.9	20.4
company size enlarged	0.5	74.4	24.7
company size smaller	6.9	66.0	27.2
investments enlarged	17.0	56.8	26.3
investments smaller	2.1	69.8	28.1
expansion employment	14.5	58.7	26.8
less employment	2.1	69.8	28.1

When a sectoral distinction is made, we fmd that for the transport and communication sector the most positive impacts are found, which is consistent with the fmdings in the regional labour market approach (section 5.2). For the service - and to a lesser extent the industry sector - relatively small impacts are obtained.

On the question how the situation would be if the highways would not have been constructed, some 10-20 % of the entrepreneurs indicates that this would have had a negative impact on employment and tlie leve1 of investments. These answers are mainly given by entrepreneurs located at less than 7.5 kilometres from a highway access (see Table 7).

In comparison to the 1989 study a substantial smaller share of the entrepreneurs indicate negative impacts of the non-construction. It appears that the positive impacts of the construction which are reported by entrepreneurs just after the construction are less evident to entrepreneurs when they are interviewed some years later.

6.3 Conclusions

In the relation between transport infrastructure and economic development the perception of entrepreneurs about the importance of transport infrastructure is of major importance.

A high consensus exists among entrepreneurs about the importance of road infrastructure and to a lesser extent telecommunication and public utilities. This common feeling about the importance of road infrastructure is partly reflected by actual location behaviour. The average distance to a highway access is decreased by 28 % after the relocation of a firm. Other relationships between transport infrastructure and the vitality of firms are less convincing. Although entrepreneurs indicate that infrastructure in general and the construction of the Al highway in particular are of a certain importance for the development of employment, they value market perspectives and intemal company considerations clearly higher. In addition, there is no clear indication of a tendency of decreasing impacts with increasing distances to an access of a highway .

The questionnaire shows that the valuation of transport infrastructure by entrepreneurs is not only based on solid rational and objective reasons, like for instance transport costs. Also subjective reasons - like image effects - are involved In 1994 the entrepreneurs indicate the impacts of the Al construction to be considerably lower than in 1989. This means that there is a reduction in the perceived importance of the Al over time.

7 Concluding remarks

In this study the impacts of highway construction on employment have been investigated with data at different spatial levels. At the highest leve1 of spatial aggregation - the Corop leve1 - it appears that only the transport and communication sector benefits from the increased national and intemational accessibility caused by the construction of the Al highway. For this sector a priori the biggest impacts were to be expected. When the reference region method is applied, it appears that no convincing indications are found that the Al construction had a positive impact on total regional employment.

It may be concluded therefore, that the impact of constructing highways on regional employment growth is not significant (except for the transport and communication sector). An explanation of this result may be that the spatial

leve1 of analysis used is too high for finding clear spatial economic impacts. It is possible that spatial effects do exist, but that these relate to distribution effects within regions. Highway construction may for example lead to relocation of firms in a region to sites near an access point. In this case one does not observe an impact at the leve1 of the region as a whole, but if data would be available at a lower spatial leve1 one would really fmd relocation effects.

The survey approach makes it possible to carry out an analysis at the individual leve1 and investigate spatial effects within regions. It appears that there is indeed a tendency of relocation of firms to move to a location nearer to the highway. In addition a positive relation between the growth of companies and the distance to the Al is found. Zones at a distance up to 7.5 kilometres of the Al have on average higher employment growth than zones at longer distances. A difficulty is that all major urban areas in the region are located within a distance of 7.5 kilometres from the highway, so that distance to highway and degree of urbanization are strongly correlated. The zone with a distance up to 7.5 kilometres to a highway is in all respects most dynamic: total employment growth, new companies and relocating companies.

Since the highway studied here is an intemational link in the highway network it is interesting to consider the intemational component of its impact. This appears to be surprisingly small. The entrepreneurs indicate that the benefits for the access to the national market are clearly higher than to the international market. Also in the study at the regional level, intemational accessibility plays a much smaller role than one might expect. This result is obviously relevant for discussions about Trans European Networks (TENS). It is probably no exception when the importance of the national dimension seems to dominate the importance of the intemational dimension of links in TENS.

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