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THE IMPACT OF NEW INFRASTRUCTURE ON THE SPATIAL PATTERNS OF ECONOMIC ACTIVITIES

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Abstract

*This article attempts to present a **systematic** overview of **the** impact of transport infrastructure on **spatial** patterns of **economic** activities.*

*The **central** element is that an improvement in **the** transport infrastructure leads to lower interaction costs. This has three major effects. First, an increase in the **access** of actors and the **accessibility** of locations. Second an increase in **the** productivity of **firms** and households. Third, a change in the volume and location of activities of **firms** and households. There also exist feed backs and **intermediate** factors which have an important impact on **the** strength and **time** period in which transport infrastructure affects **economic** development.*

The overview of approaches show that major steps forward can be made by linking modelling and non-modelling approaches.

Introduction

The impact of transport infrastructure on spatial patterns of **economic** activities is receiving increasing attention from scientists and politicians. From a political viewpoint the theme is of particular interest because of the **tension** between decreasing government expenditures and the rising **demand** for transport infrastructure. Three scientific disciplines are **active** in the field of the impact of transport infrastructure and the spatial pattern of **economic** activities: geography, **economy** and traffic engineering. **However** within none of these disciplines the theme has become a major subject of research. There has been little exchange of ideas between the disciplines and as a **consequence** the theory in this field is **rather** fragmented.

Observing the **enormous** rise in the number of - policy initiated - empirical studies in this field and considering the fragmented theoretical background, there is a need for a theoretical framework on the relation between transport infrastructure and the spatial patterns of **economic** activities. This article presents **such** a theoretical framework and an overview of methodologies involved.

It is inevitable that an adjustment in the transport infrastructure network will lead to a restructuring of traffic flows. Most important in this restructuring **process** is to which extent these **changes** in transport infrastructure networks **result** in **changes** in the total number of movements **each** zone generates or attracts. Improvements in the transport infrastructure networks lead to shifts in the relative accessibility of zones and by that to potential shifts in the number of movements from and to these zones. Those **shifts** in movements will partly occur at a short term. For **instance** the increased accessibility of a **shopping centre** leads to a **higher** number of customers. But most of these **shifts** in the number of movements will occur **after** the pattern of activities has stabilised and adjusted to the new situation. Those **shifts** in movements will settle **after** a long period of **time**. For **instance** in a zone of which the relative accessibility is increased it will take **quite** some **time** before the housing stock is enlarged, new **shopping centres** are realised and **employment** figures rise.

As shown, infrastructure improvements do not only lead to direct **shifts** in traffic flows but **also** to a long term spatial shift and extension of **all** kind of **economic** activities which **generate** or attract movements. The impact of a new link in a transport infrastructure network is not restricted to only traffic flows but it restructures the **whole** spatial pattern of **economic** activities.

The structuring impact of transport infrastructure **received quite** some

attention recently among researchers and policy makers. The impacts **can** be measured at several spatial levels. At the local **level** one might study the impact on the inner city versus the urban fringe. At the regional **level** the impact on **central** versus peripheral regions. Of major interest at the **international level** are the impacts of connections on international - Trans European - transport infrastructure networks, like the high speed rail network. **How-**ever, one has to **state** that the **often** heard positiveness of the **size** of the impacts of new infrastructure are not justified by thorough research. The results of research in this field are **rather** diffuse (Offner 1992). This article tries to formulate a solid theoretical framework and **provides** an overview of methodologies involved, on which further empirical research might be initiated.

A theoretical framework

Transport infrastructure has a long history in **economic** theory. Classic location theory and interregional trade theory are partly based on the impact of transport infrastructure. In those theories the choice of location or the interregional trade patterns mainly depends on distance between producers and customers. In those theories distance and/or transport infrastructure has been put in operation by transport **costs**.

An **explicit** theoretical approach towards **the** link between transport **infrastructure** and **economic** development is given by Voigt (1973). Voigt used **components** of several **general** growth theories to construct a development theory based on fundamental relations between the development of **traffic** systems and **economic** development. Improvements in **traffic** systems lead to hardly irreversible spatial differentiative impacts. This will lead to three types of regions: growth regions, underutilised regions and indifferent regions. Voigt assumes a **rather** mono **causal** relation between infrastructure **development** and **economic** development.

In **less** mono **causal** theories, transport **costs** are included as one of the explanatory variables of for **instance** location patterns or trade flows. **How-**ever, the relation between transport infrastructure and the regional **structure** or **economic** development never became a **main** subject of scientific research. The theme is used for different purposes by several scientific disciplines. Geographers use transport infrastructure as far as it **can** explain activities over the surface. Economists use transport infrastructure as far as it **can** help explain the functioning of **markets**. **Traffic** engineers use it as far as it gives information on the **size** and direction of traffic flows.

The attempts to **create** a broader conceptual framework are limited. Most attempts are partial approaches in which the complexity of the relation is not **fully** expressed. In the next **section** an **economic** and geographical approach is used in order to construct a conceptual model on the relation between transport infrastructure and the spatial pattern of **economic** activities.

A conceptual model - In Figure 1 the complex relation between transport infrastructure and regional **economic** development is presented. The **con-**struction of transport infrastructure **effects** the transport **costs** by means of

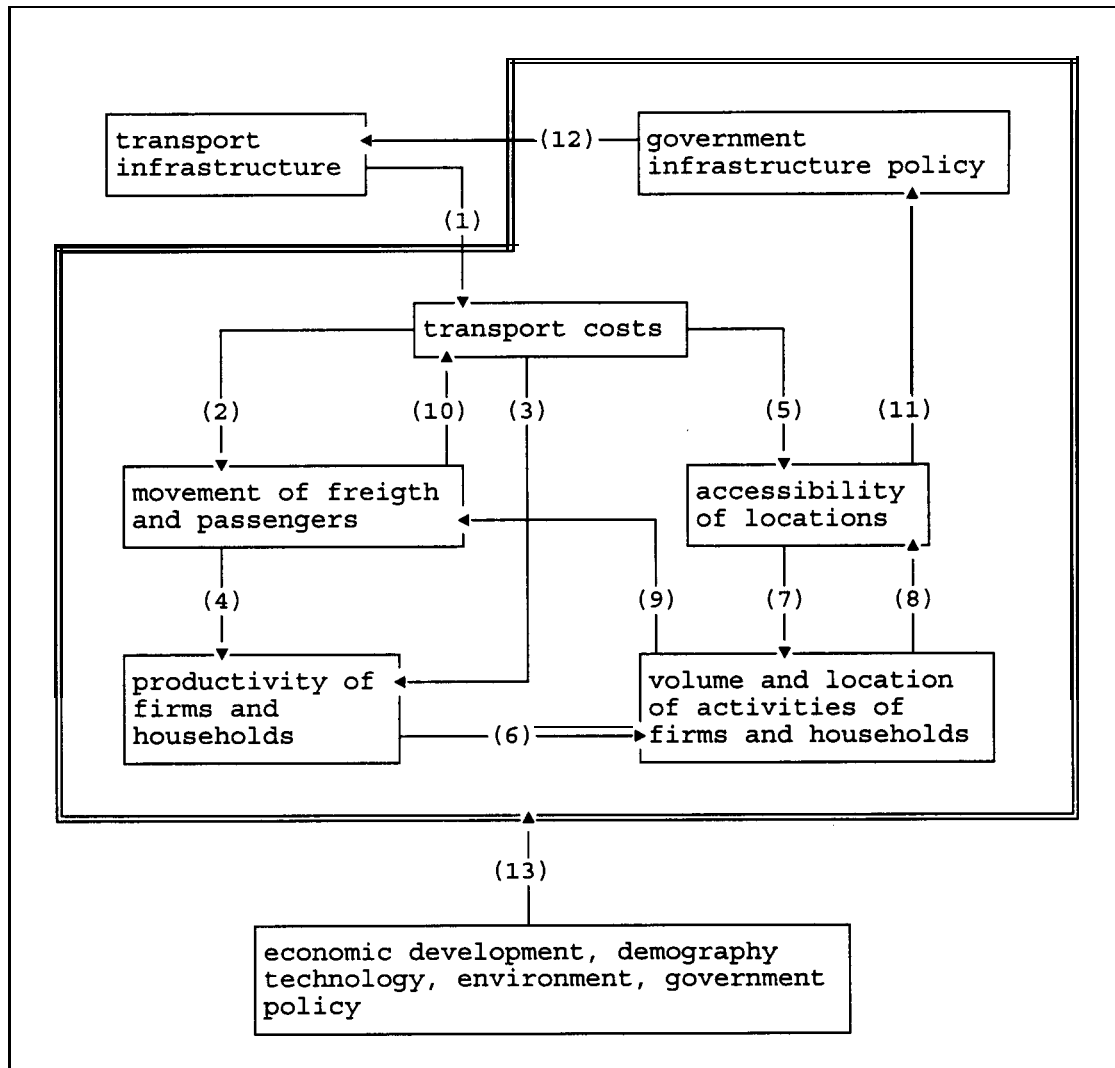


Figure 1 Conceptual model on the relation between transport infrastructure and the spatial pattern of **economic** activities

shorter distances **and/or higher average** speed (relation 1). These changes in the transport system lead to reductions in fuel, **capital** and/or wages. On its turn these changes within the **traffic** system 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).

For households this impact **can** be explained as follows. The reduction in travel **time makes** it possible to **reach** the same **level** of productivity and consumption in a shorter period of **time**. In reality at the **level** of households one **may** observe that **higher** travel speeds stimulate long distance trips. The travel **time** elasticity of household movements seems to be **rather** high. So a possible outcome is that travel behaviour of households **tends** to adapt into the direction of more frequent visits over **longer** distances instead of a rise of household productivity.

For transport and transport related **firms** an improvement in the transport **infrastructure** has its impact on the number of drivers and lorries needed to **reach** the same **level** of productivity or service. Here a substitution of private **capital** and labour by public **capital** takes **place**. This effect on transport related private **capital** and labour leads to a reduction of transport costs. This allows more transport intensive productivity, for **instance** by increasing the **frequencies** of the deliveries or by an expansion of the geographical market area.

Another possible **consequence** of the improvement of the transport **infrastructure** is an increased reliability on the exact **time** of the delivery of goods by a decreased **chance** of congestion. This **also** has a positive effect on the productivity of firms. In the case of the deliveries of goods not only the **mean** travel **time** is important but **also** the **variance** of travel **time**. A **higher** reliability in deliveries increases the smoothness of the production **process** and allows producers to **reduce** their stocks (**just in time** principle).

A last effect of the improvement of the transport **infrastructure** is the improvement of the labour market. The geographical labour market of which labourers **can** be attracted without **making** a move of the household **necessary**, expands by the improvement of the **infrastructure** network. In reality this has led to an expansion of regional labour **markets** and in some cases to long distance commuting.

The decrease of transport costs **also** leads to an increase of the accessibility of the zones involved (relation 5). The accessibility of a zone depends on **all** possible efforts necessary to visit or leave this zone. Accessibility **can** be operationalized in several manners (see Hilbers and Verroen 1993 and Bröcker 1989). One of the most **attractive** methods is to use the integral costs of movements from and to **each** zone. Those integral costs contain for **car** drivers flexible costs (for **instance** gasoline and toll), fixed costs (for **instance** interest and depreciation) and **time** costs. For the assessment of travel **time** one **can** use value of **time** studies (see Kleijn and Cheung 1989). The **time** costs **depend also** on congestion. So the accessibility of zones **also** depends on the **size** of congestion within and between the zones.

The accessibility of a zone **can** be seen as the weighted **mean** of the integrated transport costs of a certain zone to **all** other zones. For **each** motive of movement the zone need to be weighted by the mass of the zone for that **specific** motive. For **instance** for the **shopping** movements **all** zones are weighted for the **size** of their **shopping centres**.

The increase in productivity and accessibility in a certain zone might lead to an expansion of the **economic** activities **and/or** population within the zone (relation 6 and 7). A relevant implication of interregional trade theory is that a positive effect on productivity, employment and/or population is not guaranteed **when** interregional transport costs decrease. A decrease of interregional transport costs leads to an increase of interregional **competi-tion**. Firms producing for the local and regional **markets** **can** be replaced by imports from **competitive** regions. In other words, the decrease in interregional transport costs **implicates also** a decrease in the protection of regional **markets**. These negative impacts **can** only occur in the case of improvements of the interregional transport **infrastructure** networks. **Improve-ments** of local or regional transport **infrastructure** networks - like **improve-ments** in local or regional public traffic **sevices** - will not lead to those negative impacts.

Another subdivision with an important spatial component is the **difference** between generative and distributive impacts (Rietveld 1989). The generative impacts concern the total change in **economic** activities in **all** zones involved by the transport **infrastructure** improvement. The shifts in the **economic** activities will not be evenly spread over the zones. Some zones will **profit** above the **average**, others below. As a **consequence** of the restructuring of **economic** activities some zones **may** even be confronted with a decrease in **economic** activities. The **difference** between distributive and generative

impacts is especially important at low spatial levels. In the direct surrounding of for **instance** a new highway one might measure a **rather** strong increase in employment, whereas on a **higher spatial level** one measures a **shift** of employment toward this highway from more remote zones. Here the increase of employment in the direct surroundings is compensated by a decrease of employment in more remote **areas**. What seems to be a **generative** effect at a low spatial **level** might be a distributive effect at a **higher** spatial level. The spatial **level** of the area under study should be **chosen** wide enough in order to minimize the risk of measuring generative effects instead of distributive effects.

It is important to **state** that both generative and distributive effects are of **main importance** in research on the impact of new transport infrastructure on spatial patterns of **economic** activities. The target in most studies is the **size** of the generative effects, especially employment growth. **However**, from the viewpoint of for **instance** physical planning, distributive effects are as important as generative effects. There might be a need to relocate certain **economic** activities from unsuitable locations, or to steer autonomous developments, towards locations suitable for those activities. Transport infrastructure might be « especially at a low spatial **level** » an important instrument for **steering** those developments.

Until now only direct links between the construction of transport **infrastructure** and the spatial pattern of **economic** activities are given. **However**, there are a number of indirect « feedback » relations which are important.

A first feedback concerns the relocation of **economic** activities. This **relocation** implies **changes** in the masses of the zones involved. Those **changes** in the masses of the zones has its feedback on the accessibility of the zones (relation 8).

In a similar way, the **changes** in the location of **economic** activities effect the number of movements of freight and passengers (relation 9). In case of congestion this shift in the number of movements of freight and passengers implies **changes** in transport **costs** (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 might be to secure an **acceptable level** of accessibility for **each** zone (relation 11 and 12). On the other hand, the governmental **economic** policy might be oriented towards the development of additional transport infrastructure in

zones with a fast **economic** development, for **instance** to **overcome congestion**. Those two targets of government policy make clear that from a **government** perspective the construction of transport infrastructure **can** be seen as a **cause** as well as a **consequence** of **economic** development in certain regions.

A last **remark** concerns the **fact** that new transport infrastructure is not the only factor that has an important impact on the development of traffic flows and the spatial patterns of **economic** activities. In **general** factors like technology, demography, **economy**, environmental policy and **general** government policy **may** be mentioned (relation 13). Those factors shape a wider context in which the relation between transport infrastructure and the spatial pattern of **economic** activities has to be analyzed. Above this, it is important to understand that those factors have a major impact on the strength and **time** period in which transport infrastructure has an impact on spatial patterns of **economic** activities. This **means** essentially that a multivariate approach is called for.

Research methods

In this paragraph an overview 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 (**see** for a more extended overview Bruinsma and Rietveld 1992). An overview of approaches is given in Figure 2.

	Models	Other approaches
Aggregate data	<ul style="list-style-type: none"> - transport land use models - production function models ▪ location models - interregional trade models ▪ general equilibrium models 	<ul style="list-style-type: none"> • quasi experimental
Desaggregate data	<ul style="list-style-type: none"> ▪ stated preference models ▪ revealed preference models 	<ul style="list-style-type: none"> ▪ quasi experimental ▪ entrepreneur survey ▪ expert judgement ▪ calculation of the impact of infrastructure on transport costs

Figure 2 Research methods

In Figure 2 a twofold subdivision is used. First there is a subdivision between models and other approaches. **Second** there is a subdivision based on the spatial **level** of the data input. Behind this double subdivision **lay** two arguments. In recent research activities a sharp division exists between models and other approaches. In my opinion linking those two approaches will **result** in major steps forward from a methodological point of view. Even more it might lead to new empirical results and give new **evidence** in the complex relation between transport infrastructure and the spatial pattern of **economic** activities. So far only a few attempts in this direction are known (for **instance** Spiekermann and **Wegener** 1992). The **second** argument is that the availability of data is **still** a serious bottleneck in research in this field. A number of approaches get **stuck** in their further development **and/or empirical** elaboration because of shortcomings of data sets. Data are not available at the correct spatial **level** and/or the desired subdivision into infrastructure **components** etcetera.

Another possible division might have been a division of approaches in infrastructure **components** (road, rail, air, etc.). This division has some close links with the spatial aggregation **level** of research. At the urban **level quite** some research is oriented towards **specific** urban infrastructure networks like city rail (Berechman and Paaswell 1983, **Bajic** 1983, Cervero 1984, Hall and Hass-Klau **1985**), orbital motorways (Bayliss **1990**, **Bruinsma** et al. **1993**), sight locations (BCI 1990, Jansen and Heijs 1992, **Korteweg** 1992) and railway station locations (Sprangh and Van Tongeren 1983, Jansen and Van der **Sterre** 1986, Bongenaar and Olden 1992 and NEI 1994). Another type of infrastructure which is receiving special attention at the interregional **level** is the high speed rail line (Bonnafoos 1987, Ter Brugge and Pellenbarg 1988 and Plassard 1991).

Such a division in infrastructure **components** will give a **rather** diffuse overview of approaches while most approaches are used for several **infrastructure components**. Here the approaches will be dealt with conform the double subdivision of Figure 2.

Models based on aggregate data - Active it this type of research are traffic engineers and economists. The models developed by traffic engineers are based on the traditional transport models. Those traditional models are not **capable** to analyze the impact of transport infrastructure on spatial patterns of **economic** activities, **however**. In those models the locations of activities like work **places** and houses are given. In the integrated transport land use

models this **static** situation is **left**. Those models try to **incorporate** the **generation** of new movements in the analysis. The transport land use models are developed for the urban **areas**. An overview of those models is given in **Webster et al. (1992)**. Some Dutch attempts to develop an integrated transport land use model are given by **Hamerslag (1975)**, **Hamerslag and Immers (1991)** and **Hamerslag, Van Berkum and Repogle (1992)**.

An important element in most integrated transport land use models is that the total **size** of population and employment of the urban area is given. This **means** that the model outcomes only give information about the spatial spread of activities over the city surface and nothing about the total **size** of the activities. The models analyze distributive effects of infrastructure improvements instead of generative **ones**. Therefore, if one **still** wants to deal with generative **aspects** one has to feed a transport land use model with information of a multi-regional model, like for **instance** an interregional trade model. Nevertheless, even with only the use of a transport land use model at least some expectations about generative effects **can** be given. Generative effects of an infrastructure improvement are expected if one observes an increase in productivity in a city. This increase in productivity will be realised by a decrease in transport **costs caused** by a decrease in distance **and/or higher** speed. In which matter this decrease in transport **costs contributes** to a more **attractive** urban production environment depends of course on the infrastructure improvements in competing cities, which are beyond the **reach** of the model.

The **economic** models analyze **how** transport infrastructure effects the regional production **structure**. The production function approach, the location approach and the interregional trade models are **all** focused on this regional level. The lower transport **costs caused** by the improvement of the interregional transport infrastructure networks **result** in an increase in the accessibility of regions. As a **consequence** the geographical market area will expand. A rise in productivity occurs via the **higher** returns to **scale caused** by this expanded market.

In the production function approach the **level** of production depends on the classic private production **factors - capital** and labour - and transport **infrastructure**. The public sector **provides** the transport infrastructure in **moste** cases free of charge. Improvement of the transport infrastructure has a positive impact on the **level** of productivity of the private production **factors**.

This rise in productivity **may result** in **higher** wages for the employees, **higher** profits for the producers, lower **prices** for the consumers or a combination of those **effects**.

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 for an overview Rietveld 1989). A common problem researchers are confronted with is the poor availability of data concerning private **production** factors at the desired **sectoral** and/or regional subdivision. As a **consequence** in most studies incomplete quasi production functions are used (see for **instance** Blum 1982 and Nijkamp 1986). Another complication is that the impacts of transport infrastructure might cross regional borders. For **instance** the impact of a national **airport** will **also** be measured outside the region **where** this **airport** is located. Aschauer (1993) tries to solve these **shortcomings** by applying the production function at the national level. **However**, desaggregation of results to the regional **level** is then impossible (Munell 1993).

One of the lessons that **can** be learned from the production function approach is that ongoing improvements of transport infrastructure will **result** in a lower growth of the regional value added (**law** of decreasing returns to **scale**). **However**, if the other production factors - **capital** and labour - show a growing tendency there might occur a bottleneck if the **level** of the transport infrastructure remains constant. This bottleneck **may** have a negative impact on the productivity of labour and **capital**.

Improvement of transport infrastructure in a region leads to an increase in the productivity of private production factors as ascribed above. In its turn 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 might 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).

The results of location factor models are **rather** diffuse (**compare** Botham 1983, Dodgson 1974 and Kau 1976). This is mainly **caused** by the difficulties to **define** some of the essential parameters and the poor availability of desaggregated investment data.

The interregional trade models are more sophisticated and detailed if one wants to analyze the impact of changes in interregional transport **infrastructure** networks on regional **economic** development. Those models need to contain at least the next three elements (Amano and Fujita 1970):

- a link between transport infrastructure and transport costs,
- a link between transport costs and traffic flows,
- a link between traffic flows and regional development.

Those models need a **very** detailed input of data. As might be expected the researchers fail in **feeding** the model properly in most cases, therefore.

There are **also general** equilibrium models available in which transport **components** are incorporated. Those models show two weak spots **concerning** the pricing of transport costs (Van den Bergh 1992). First, those models suppose that the **markets** of transport services are flexible. This **means** that **demand** is always equal to supply. The supply of transport modes is **supposed** to be **elastic**. In reality there is no **such** supply elasticity, **however**. **Investments** in infrastructure - as well in the physical network as in rolling stock - are **rather time** consuming. It takes a relative long period of **time** before transport infrastructure is adjusted to changes in **demand**. **Second**, the **general** equilibrium models are based on the functioning of perfect **markets**. **However**, the transport sector **can** be characterized as an imperfect market. There exist monopolies (national railway **companies**), public goods and externalities (for **instance** congestion).

Models based on desaggregate data - Revealed and stated **preference** approaches are most common in attempts to study the impact of transport infrastructure on spatial patterns of **economic** activities with models using data on a desaggregate level.

These approaches are implemented at different spatial levels. Both approaches are based on individual utility functions. In the case of revealed **preference** models the utility function is fed with data concerning choice behaviour in actual situations. In case of stated **preference** the data concerns preferred behaviour of respondents **who** made a choice in a laboratory situation.

The revealed **preference** models show four weaknesses (Kroes and Sheldon 1988). First, it is hard to get enough variation in the data set in order to allow an analysis of **all factors**. **Second**, there **often** appear to be strong correlations between some of the independent variables. For **instance** travel

time and travel costs are correlated **rather** close. For **each** transport mode **holds** that the **longer** the trip takes the more expensive it will be. It is difficult to estimate the utility of those closely correlated **factors**. Third, revealed **preference** data only **can be collected after** the improvement in the transport infrastructure network is realized. It is not possible to make predictions in an early stage of development. Especially for transport infrastructure it is **already** in the phase of decision **making** of great interest to have information about the traffic flows **after** the realisation of the network improvement. Fourth, revealed **preference** models allow only the use of direct variables like travel **time** and travel costs. The models are **less capable** to deal with indirect variables like travel comfort or the quality of railway station facilities. Since the stated **preference** models use hypothetical assumptions in a laboratory situation they **can cope** with most of the weaknesses of the revealed **preference** models. The **main** weakness of this type of models is that the actual behaviour does not necessarily correspond with the **preferences** given. For instance, people might say - for a number of reasons - to **expect** to make use of a new highway but **after** the realisation this **expectation** might not be translated in actual behaviour.

The need for information on expected traffic flows before the decision is taken to construct a new link in an infrastructure network has led to attempts to combine both methods. Revealed and stated **preference** models have to be seen as complementary instead of opposite, therefore.

Other approaches based on aggregate data - The quasi experimental approach is the most common used non-model approach based on **aggregate** data. In this approach the development in a region is analyzed **after** an improvement of the **internal structure**. This development is compared with the development before the improvement and/or a group of reference regions. The traditional quasi experimental approach contains four **applications** (Isserman 1990).

- the situation **after** the improvement is compared with the situation before,
- the situation **after** the improvement is compared with the situation in reference regions **where such** an improvement did not take **place**,
- both the before as the **after** situation are compared with reference regions
- regions **where** improvements have taken **place** are linked to reference regions on basis of a similar development in the before period, then **after** development is compared.

The **main** objection of Isserman (1990) is that those methods are focused on

differences between two groups of regions (regions with improvements versus regions without improvements) and the **general tendencies** between those groups. The individual regional **variance** is neglected. This individual regional information is lost by analyzing **average** developments. Another problem of the quasi experimental approach is the need for a large numbers of observation (regions). The approach is of little use in a **small** country with a limited number of regions like the Netherlands (Bruinsma et al. 1995a).

Other approaches based on desaggregate data - Approaches in which desaggregate data are used, are implemented at **all** spatial levels. Especially international oriented empirical studies apply these **rather** qualitative approaches. On this spatial **level** modelling is **still** limited.

The quasi experimental approach use the same **technic** as ascribed above. The only **difference** is the spatial **level** at which data are **collected**. Here data are **collected** at the **level** of individuals instead of regions.

Surveys among entrepreneurs are **quite** popular among researchers. Those surveys might be **postal** questionnaires, telephone interviews or face to face interviews. There are two **main** targets to distinguish. The first one is to **trace** the impact of transport **infrastructure** on locational decisions of firms. The **second** target is to measure the impact of **the** construction of new transport **infrastructure** in case of bottlenecks in the existing network (see **Diamond** and **Spence** 1989 and **Bruinsma** et al. 1995b).

The information obtained from these surveys **may** not be free from **subjective** judgements. Those **subjective** judgements are not always unconsciously given due to a **lack** of information. In the case of a study on the impact of transport **infrastructure** on locational decisions an entrepreneur **who** has taken the wrong locational decision **may** try to disguise his **mistake** by giving an overly optimistic view of his present location. The entrepreneurs might **also** give an overly optimistic view of the impact of a future transport **infrastructure** improvement because he **expects** that this might **accelerate** the decision **process**.

However, one has to realize that it is extremely **difficult** for a entrepreneur to **indicate** the impact of transport **infrastructure** on his firm. In case of the locational decision there are **many internal** and **external factors combined** in the **final** decision. Transport **infrastructure** is one of them just like the preferences of his wife c.q. husband. The researcher has to **create** a broad context of impact **factors** to prevent that the entrepreneur overestimates the

importance of transport infrastructure.

Nevertheless this type of research is **very** important. In reality an **entrepreneur** takes a decision to (re-)locate his firm based on imperfect information. The **perception** of the entrepreneur of the potential location and some alternatives is of **main importance**. Only with surveys of this type the **process** leading to the **final** location decision **can** be reconstructed.

The **difference** between a survey among entrepreneurs and expert judgement is **rather** small. Here, we consider an approach as an expert judgement instead of survey if the information requested concerns not only the - spatial location - of the own firm, but a more **general** view of the impact of transport infrastructure on **economic** development (for instance Healey & Baker 1990-1993).

In a number of research **projects** on the impact of transport infrastructure and spatial patterns of **economic** activities, experts have to weigh the independent variables. The phase of research in which weights are given varies **across** these studies. **Also** the weighting procedure **can** refer to different elements of the research project (**compare** NEI 1987 and Cheshire et al. 1986).

A last form of expert judgement concerns Delphi-like research approaches in which consensus among experts is aimed at **via** iterative procedures.

A completely different approach for achieving knowledge on the impact of transport infrastructure on the spatial pattern of **economic** activities is by calculating the gains in transport **costs** of potential users as a **result** of an improvement in the network. The impact is measured in reduced travel **times**, which are evaluated in a monetary way for **each** travel motive. Important travel motives are: freight traffic, business travel and non-business travel. Non-business travel is **often** subdivided in commuting and leisure **time** trips. The crux in this type of research is the monetary evaluation of those travel motives (De Jong et al. 1991). In the Netherlands freight traffic is evaluated by wages of drivers, fixed **costs** of **car** use **and/or general company** overhead **costs**. The business trips are evaluated by a percentage of the gross wages in which National insurance contributions are included. Those monetary evaluations are widely **accepted** (only the levels of the percentage of the gross wages is disputable). Less consensus exists on the monetary evaluation of non-business trips, which are **often** evaluated by a percentage of the wage **level**.

Conclusion

The impact of transport infrastructure on spatial patterns of **economic** activities has **received** - from at least a **theoretic** point of view - **little systematic** attention until now. This article attempts to give **such a systematic** approach.

The **central** element in this approach is that an improvement in the transport infrastructure leads to lower interaction costs, which **may** have three major **effects**. First, the **access** of actors increases and by that the accessibility of locations increases. In the **second** place the productivity of firms and **households** increases because of the decrease in interaction costs. Third, this increase in productivity of firms and households and the increased **accessibility** of locations have an impact on the volume and location of activities of firms and households; the spatial pattern of **economic** activities.

Above those direct impacts it is important to **notice** a number of feed backs and intermediate **factors**. The intermediate **factors** have an important impact on the strength and **time** period in which improvements of transport **infrastructure affects** the spatial pattern of **economic** activities. It is of major **importance** to make an inventory of the **whole** regional context in which the improvement of a transport infrastructure network takes place. The research should cover **all** the elements of this inventory list.

The impact of a transport infrastructure improvement has to be seen in the light of the **general** - regional, national and international - **economic development** and the prevailing government **policies** on **areas** like for instance investment subsidies, environmental issues and technological development.

The overview of approaches in this field shows that in particular models are commonly **accepted**. Nevertheless those models are sometimes **stuck** in their further development by poor availability of data. The research on the impact of improvements of transport infrastructure on the spatial patterns of **economic** activities has flourished on the urban and regional level. At those **levels** of spatial aggregation a number of different models are available. At the international **level** the number of models is limited and the research is more based on qualitative approaches. To my opinion by combining different models - for instance a transport land use model with an interregional trade model - or by relating a model with a non-model approach - for instance a location model supplemented with an expert judgement approach - at different **levels** of spatial aggregation some major steps forward **can** be made in increasing the knowledge on the impact of transport infrastructure

on spatial patterns of **economic** activities. Those mixed approaches **may** lead to new empirical results and new **evidence** in this complex relation. , In view of the limitations inherent to **each successive** approach it is **advisable** to apply in new empirical and/or policy oriented studies several • linked • approaches.

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