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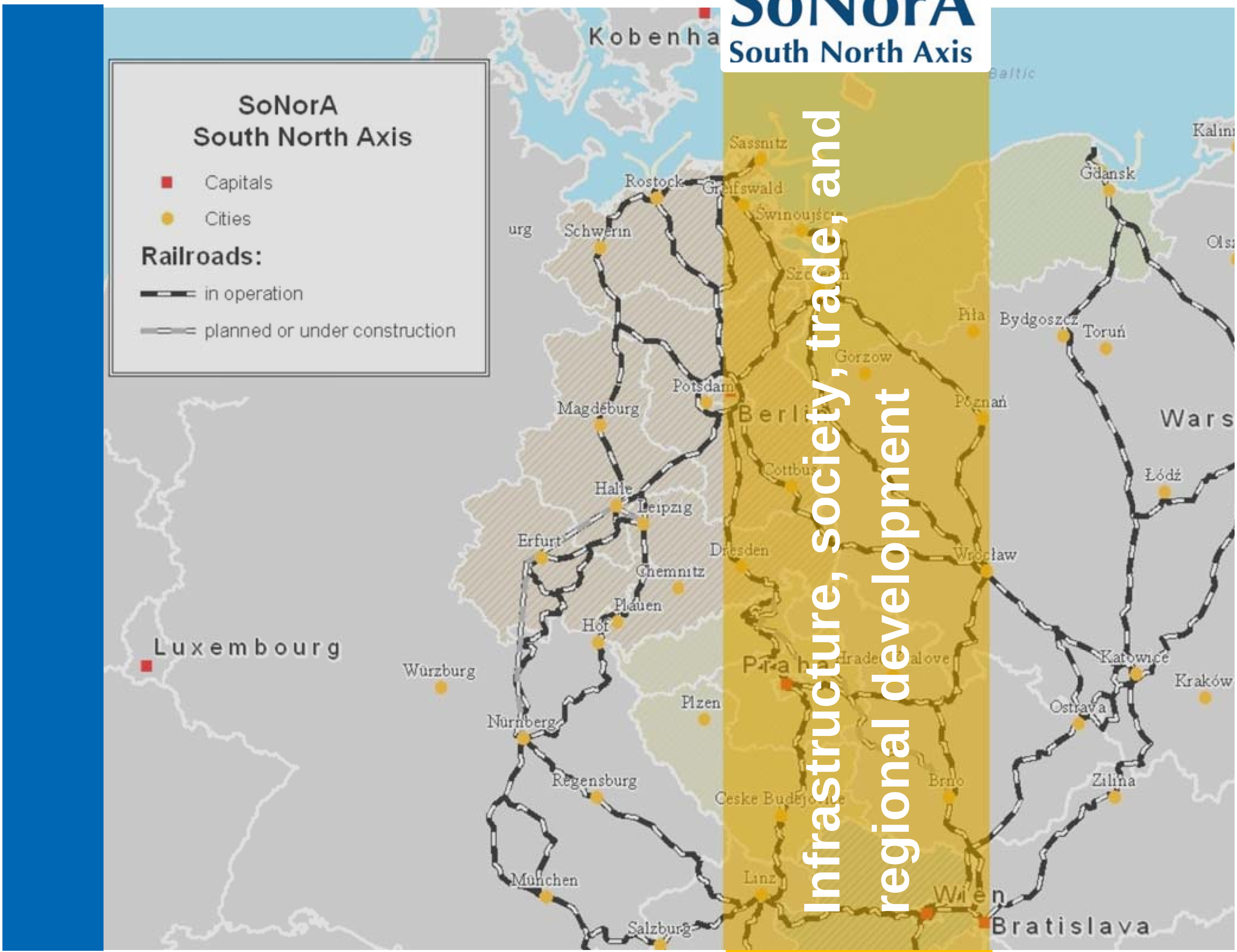
SoNorA South North Axis

Infrastructure, society, trade, and regional development



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Infrastructure, society, trade, and regional development

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INTRODUCTION

SoNorA (South-North Axis) is a transnational cooperation project of the European Union which aims to improve the infrastructure and services in the south-north orientation within Central Europe. An integral and important part of SoNorA is the University Think Tank as a network of transport scientist which has three main roles and tasks within the project:

Firstly, it aims on the creation and consolidation of a network of universities in Central Europe which are related to research and education in transport and/or spatial planning. These partners participate in SoNorA conferences, round-table discussions, the writing of scientific articles, and further research projects emerged out of SoNorA.

Closely related to point one, the second task of the Think Tank is to generate inputs for the whole project. The Think Tank gives methodological support to project partners and creates strategies and inputs for SoNorA. These scientific papers are presented on separate conferences during the regular SoNorA consortium meetings.

Thirdly, the Think Tank reviews the 24 core outputs of the project which are generated by the project partners. The core outputs will be presented to the Think Tank by the partners on the consortium meetings and then will undergo a scientific review process including ex-post-analysis and best-practice identification.

The third SoNorA University Think Tank conference was held on the 11th of November 2009 in Potsdam (Germany) and was focused on the topics of TEN-T core network and on European and national railway policies. The Think Tank consists of transport researchers of different faculties of various Central European countries. It is planned to organise ten Think Tank conferences, thus one on each consortium meeting. Each conference deals with a specific topic of transport research which is related to the content of the core outputs to be delivered on that time. The topics of the past and future Think Tank conferences are the following:

No	Date	Place	Topic
1	Feb '09	Praha	Get to know
2	Jun '09	Gdynia	Transport infrastructure between the Adriatic and the Baltic Sea; Transeuropean Networks of Transport in Central Europe; Simulation and modelling, forecasting and infrastructure
3	Nov '09	Potsdam	TEN-T core network; European and national railway policies
4	**Feb '10**	**Portorož**	**Infrastructure and regional development;** **Infrastructure, transport and trade;** **Infrastructure and society**
5	Jun '10	Erfurt	Transport in the wood-paper / solar-wind sector; Economic cooperation; Logistics services; Stimulation of value added services for transport chains

6	Oct '10	České Budějovice	Future of rail freight; Future of inland waterway freight
7	Feb '11	Trieste	Harbour hinterland transports
8	Jun '11	Szczecin	Transport and the environment; Sustainable transport
9	Oct '11	Bologna	Preparation final conference
10	Feb '12	Venezia	Final conference

The topics of the 4th SoNorA University Think Tank conference are:

- Infrastructure and regional development
- Infrastructure, transport and trade
- Infrastructure and society

Selected members of the Think Tank have written five scientific papers on different aspects of these topics which were presented at the conference in Portorož, Slovenia, on the 25th of February 2010. The authors are from the Leibniz Institute for Regional Development and Structural Planning (Germany), the Széchenyi István University in Győr (Hungary), the Technical University of Berlin (Germany), the University of Maribor (Slovenia) and the University of Applied Sciences Erfurt (Germany).

The papers are dealing with knowledge potentials of improved societal and knowledge linkages, system dynamics in transportation as well as the strengthening of Mediterranean ports. Furthermore the relative importance of transport infrastructure investments and its spatial impacts and effects are described and discussed.

This is the third volume of a series of “Proceedings of the SoNorA Think Tank Conferences” where all accepted contributions of the authors are presented. It shall provide a basis for further discussions and be the start of a successful scientific network in the field of transport and spatial planning.

KNOWLEDGE POTENTIALS OF AN IMPROVED LINKAGE ACROSS A TRANSNATIONAL DEVELOPMENT CORRIDOR

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ABSTRACT

This article, which is based on investigations into economic structural change, elaborates on the interaction of different knowledge society based parameters, their prerequisites (such as norms and rules) and their implications on spatial development. Starting with a short theoretical reflection of "proximity" and its physical and relational dimension, it is shown in the case of a German region (Münster-Osnabrück) that institutions with particular knowledge societal characteristics and the borders of their scope are an important frame for spatial development in physical terms. It is shown for the whole of Germany that this development results in fundamental spatial patterns, which have different requirements in terms of infrastructure and institutions. Accordingly, the development endeavours in the Baltic-Adriatic corridor require widening the range of strategies from those which focus on built infrastructure to those which affect framing institutions. Against this background, efforts need to be made to know how the knowledge society in the Baltic-Adriatic corridor is configured spatially and which institutions could be introduced or changed to contribute to a transnational development meeting the knowledge societal demands.

1 INTRODUCTION

Knowledge was already considered an important resource by the industrial society and a motor for the development of society and its spaces. In comparison, today's visible transition to the knowledge society is distinguishable through a qualitative leap in the way knowledge is produced, shared, and used. With the societal change the perception of development potential changes. This holds for all spatial levels and, therefore, for transnational corridors as the Baltic-Adriatic one, as well.

There are numerous spatial potentials in this corridor covered by the two Interreg projects Scandria and SoNorA. In the European macro-region stretching from Scandinavia to the Adriatic See some of the most innovative economical and cultural centres of Europe are located. Especially the resource knowledge, both in economy and science, provides economic and cultural potentials. These spatial potentials concentrate in the metropolises of the corridor and comprise highly innovative and fast growing branches like biotechnology or the cultural economy as well as traditional but also innovation based industries like the automotive and maritime sector [1].

But, the linkage in terms of cooperation and communication activities between the economic centres of development is poor. And, furthermore, the disparities between these centres and their hinterland prove to be considerable. This holds for the development of both the knowledge economy in particular and the knowledge society in general. This paper is meant to show that the knowledge society differs from the industrial society in that it establishes special networks and that this has particular implications on institutional and infrastructural requirements, necessary to foster a more favourable spatial development. This has implications in two respects:

Firstly, in a causative sense, knowledge society's actors not only estimate and evaluate proximity and distance according to physical, but also according to other (e.g. cognitive or institutional), more relational dimensions [2], [3], (section 2.1). In pre-industrial and industrial society, however, physical space, with its patterns of specialisation, dominated the actors' behaviour. It formed a space for action which costs a great deal of time and energy to overcome. In the knowledge society the perception of space is still valid, but is to be extended to further dimensions, in particular the institutional one. This will be shown basing on a case study (section 2.2).

Secondly, in a practical sense – related to politico-administrative necessities –, the knowledge society causes a reconfiguration of space [4]. In the case of Germany it will be shown that this results in three fundamental spatial patterns, which have different requirements in terms of infrastructure and institutions (section 2.3).

This paper will close with an outlook on how these insights of spatial trends possibly could be utilised to foster corridor development by strengthening and exploiting its economic potentials in the case of the Baltic-Adriatic Development corridor (section 3).

2 SPATIALISING KNOWLEDGE SOCIETY

2.1 Physical and relational proximity as parameters of distance

Theories about how spatial patterns of the knowledge society will develop have been fragmentary and rather vague up to now. One reason for this is the invisibility of knowledge, knowledge flows, and knowledge spillovers. In his standard work “Geography and Trade” Paul Krugman noted that it is impossible to observe knowledge flows: “They leave no ‘paper-trails’ by which they can be measured and tracked, and there is nothing to prevent the theorist from assuming anything about them” [5, p. 53]. If the industrial age was about the visible and systematic ordering of the spatial functions, the organisation of transport, the transport of material goods between spatially separate types of function, and about the balance of interests between the largest social groups (workers, employees, and capital), the knowledge society’s driving forces are less visible [6, p. 252].

Exchange of knowledge and collaborative knowledge generation, as constitutive elements of the knowledge society, take place among an increasing variety of actors. Crucial for the success of these interactions is the quality of relations between involved actors. Although new information technologies offer new options for personal interaction across long distances, face-to-face interaction remains important [7]. Face-to-face interaction is necessary to handle with insecurities and ambivalent information. It is also indispensible to generate an atmosphere of trust. On the one hand this means that spatial co-location, permanently or temporarily, is still necessary, resulting in a demand for highly effective transport infrastructures linking the places of collaborative actors and “minimising” physical distance by reducing travel time. On the other hand a situation of co-location not necessarily means that meaningful interaction will take place. The actors have to speak at least one common language and a common cognitive or social background is helpful as well. The more complex the goal of interaction the more important the relations between the interacting individuals become. For successful project cooperation, for instance, also organisational and institutional distances are relevant, and you could easily add some more possible dimensions of distance. We subsume these interaction influencing distances, occurring from the relations of actors, under the category of “relational” distance [3].

Therefore, successfully linking spatial potentials of a corridor not only affords investment in transport infrastructure. This would reduce travel times, probably enhancing the possibility of co-location, but not necessarily enhancing the quality of interaction taking place within the corridor. Policies are not able to achieve proximity in all relational distances as some of these are very persistent and some might even result in a productive diversity. But experience has shown that especially institutional borders, established by the scope of rules and policies, resulting in institutional proximity or distance, described by being either within or without such scopes, can have major impacts on regional cooperation practice and potentials. This will be shown in the following section using the case study of the German region of Münster and Osnabrück.

2.2 Case study: institutional borders of the Münster-Osnabrück region

The cities of Münster and Osnabrück, in the North-Western part of Germany, are quite close to each other, the distance being 56 km on the motorway, 24 min by Intercity, and 36 min by regional trains. Both of them were host to the peace consultations in the 17th century to stop the Thirty Year's War. The final treaties were named after the two cities. Apart from this mutuality in history, even in modern all day's life the two cities seem to be part of a single region with the airport Münster/Osnabrück lying in between. But, still this is not reflected in political, administrative, or economic structures.

Instead, the regional context of this part of Germany remains complex, as can be shown in figure 1. The case here are concepts as they can be witnessed in knowledge society. They are highly dependent on institutions, e.g. the politico-administrative structure, the cognitive background of scientists, national respectively ethical entities.

Basically, the figure discloses the localities of networks. The forms of knowledge exchange and sharing within networks are fundamentally different from the forms of the traditional division of labour, as it is known from the industrial society, where tasks have been separated in order to achieve economies of scale and to reduce production costs. Instead, knowledge societal concepts show a combination of knowledge through network-like communication, thereby fostering existing development trajectories, the emergence of new ideas and insights, the stimulation of learning and innovation processes.

There are networks of two kinds: those consisting of selected cities – or even more accurate: localities – and those being more or less territorially bound. A further distinction can be made respecting the scale of the networks (regional or supra-regional scale).

The territorially bound networks usually have a regional scale and combine municipalities and districts representing local and regional authorities. Their objective is to develop the region and to reduce disparities. As an example, figure 1 discloses the business development scheme “Aktionsgemeinschaft Wirtschaftsförderung Münsterland”, which stretches out over four districts plus the city of Münster. Furthermore, these authorities are part of the Euregio, which stimulates and facilitates cross-border cooperation in the working fields of socio-cultural cooperation, socio-economic development, intermunicipal cooperation, advisory services, and inter-regional cooperation. It spans over a region composed of some Dutch provinces and (parts of) German districts, among them the Münsterland and the area of Osnabrück.

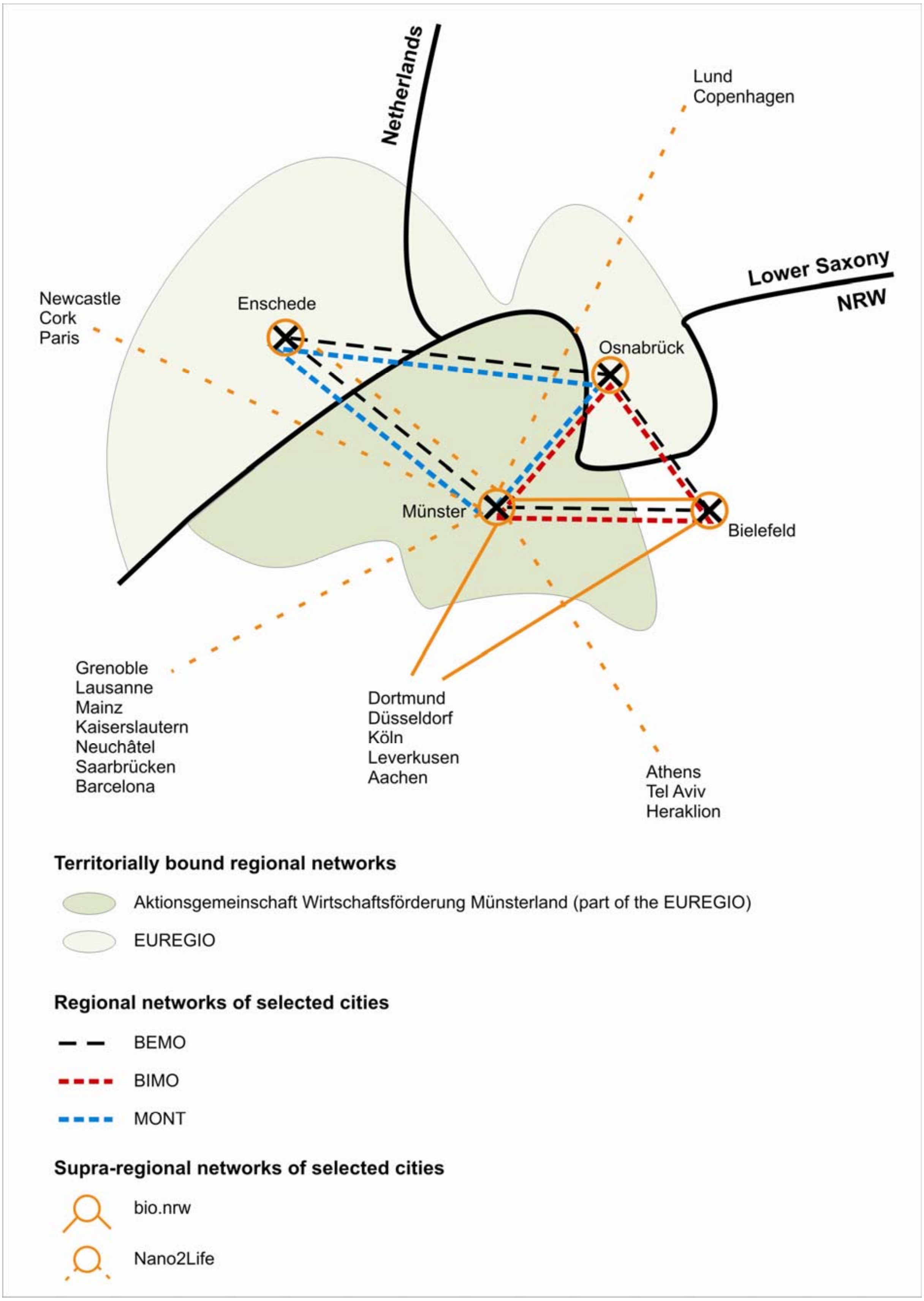

Figure 1: Knowledge societal concepts in the area of Münster and Osnabrück (own illustration)

The territorially bound networks have a relatively wide range of tasks and objectives, whereas the networks of selected cities, which span in the same area as the Euregio, highlight specific issues. But, although historically developed trajectories, the established Euregio, and all day live suggest cooperation in this area, there still is no clear concept, what should be the places forming the city network. The widest perception has been the “BEMO”, consisting of the cities of Bielefeld, Enschede, Münster, and Osnabrück. It was being discussed at the time of the millennium change, but it is not followed any more, just as “BIMO”, the same network restricted to the three German cities. Actually, the biggest attention is given to “MONT” – with “NT” standing for the “network city Twente” consisting of Enschede and some neighbouring cities. MONT is meant to intensify communication and cooperation between the network city, Münster, Osnabrück, and now even some of the smaller cities in between to “make a firm stand by distinguishing themselves from other cities in the European arena of forces” as it is phrased on the homepage “www.mont3.eu”.

Extending the spatial focus, cognitive knowledge spaces can be discovered stretching between the locations of scientists who have complementary research themes. In the case of Münster and the scientific field of nanobiotechnology, its important knowledge economy base, there are networks including the other outstanding research and production localities in the state of North Rhine-Westphalia (NRW) (bio.nrw) and the – in terms of physical distance – even wider network “Nano2Life” with locations in the north-west (e.g. Newcastle), north-east (e.g. Copenhagen), south-east (e.g. Tel Aviv), and south-west (e.g. Grenoble) of Europe.

The specificity of knowledge therefore means that the knowledge society’s spaces will, to a great extent, consist of networks which only overlap territorial spatial categories to a certain degree, and will in part consciously ignore them. But, the territorially bound institutions still prevail. As an example, the spaces forming the home base for politicians are rather states, such as NRW or Lower Saxony. These state institutions, therefore, form pull factors via the reference points of politicians. This is a major reason why the attempts to develop a particular “region” with Münster (NRW) and Osnabrück (Lower Saxony) as centres, bridging the state barrier between these cities, are not pursued any more.

2.3 Reconfiguration of space

As made obvious in the previous section, spaces of the knowledge society are especially constituted and shaped by networks embedded in various institutional settings. These networks and institutions are often spatially bound or at least possess a spatial dimension, thus constituting regional contexts. For the German case it can be shown that the spatial context of the knowledge society is given in regions, which consist of cities and districts with different knowledge societal profiles. The interplay of these different locations and spaces in regional contexts is particularly important for understanding the spatial reflection of the knowledge society. Taking a closer look at the reconfigured spatial structure, three very specific knowledge society relevant spatial patterns become apparent: upscaling, corridors of development, and new periphery (cf. figure 2). Although the empirical base and the examples for description are German, the patterns identified may apply to other countries or macro regions as well.

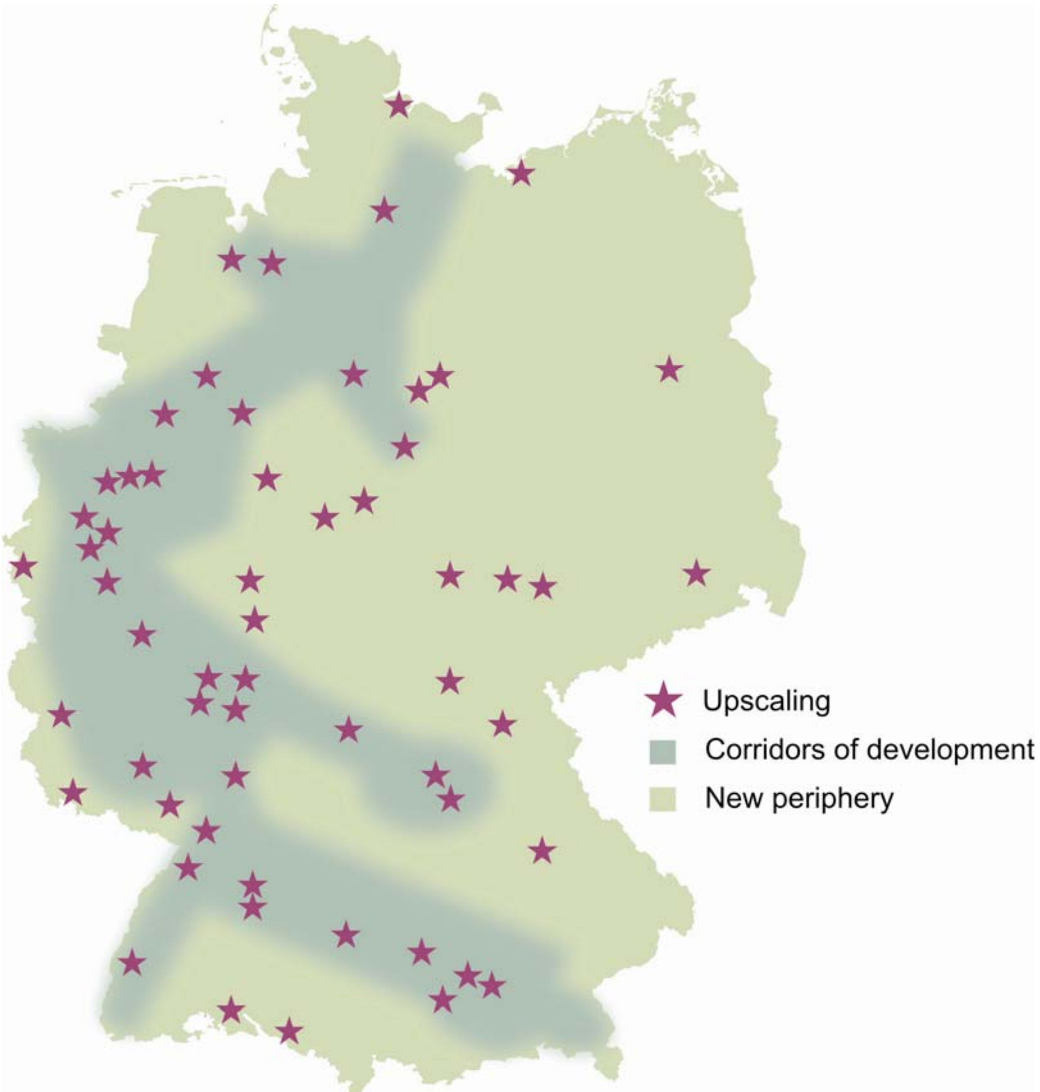

Figure 2: Prevailing spatial patterns of the knowledge society in Germany (own illustration)

The elaboration of the three identified spatial patterns includes several steps and is mainly based on multivariate statistical analysis of secondary statistical data on the spatial level of the German "Landkreise" (districts) and "kreisfreie Städte", comparable to NUTS 3 regions. Fifteen variables[1] representing the economic, social and technical dimensions of the knowledge society represent the empirical basis of the conducted factor and cluster analysis. The first factor, "science and education", has a high correlation with indicators of the social dimension as well as with public sector employees in the knowledge society, i.e. employees at universities, adult education institutions, libraries, archives, museums, botanic gardens, and zoos. Furthermore, an average correlation is found with employment in research-intensive professional groups. The economic dimension of the knowledge society is represented in the two factors "information, technology, transaction" and "high-technology". And finally, there is a high degree of correlation between the "infrastructure" factor and the indicators of the technical dimension. A following cluster analysis provides us an intricate

[1] These include variables considering employment and functional specialisation of knowledge intensive sectors, R&D activities, patents as output of knowledge intensive work, human capital (students and educational level), IT and transport infrastructure.

spatial pattern of the German knowledge society. Based on this cluster analysis the three spatial patterns introduced above can be identified.

2.3.1 Upscaling

Knowledge society based attributes concentrate in prominent knowledge society hubs. These are, with a few exceptions, the large metropolitan centres. Each of them has a distinct knowledge society related profile from which a functional division of tasks within the German urban system can be deduced. Another phenomenon produced by the knowledge society's dynamism is the prominent role of extended metropolitan regions. Agglomerations such as Munich, Rhine-Main, Rhine-Ruhr, Hanover Region, Nuremberg, and Stuttgart consist of a leading service centre and numerous neighbouring cities that each have their own specialisation. These regions represent the diversity of the knowledge society. Furthermore, diversity within the regions themselves is an expression of the specificity of qualification and knowledge requirements. Individual cities only prosper within this context, when critical masses of knowledge society relevant factors are available ("economies of scope"). Such factors include R&D facilities, high-technology firms, knowledge-intensive service providers, and suitable infrastructures of literacy, education, and communication. In spatial development policy concepts for metropolitan regions and knowledge regions this tendency of spatial upscaling is being focused on with varying degree of intensity. But there is some evidence, for instance from the Rhine-Neckar region, that a policy, which provides territorially effective institutional settings to foster cooperation through linkages within and beyond the administrative boundaries, can help exploiting economic territorial potentials.

A special role is played by cities which are strongly influenced by science and education but that do not have prominent positions in high technology and service fields within the knowledge economy. The spectrum stretches from large individual metropolitan centres (Berlin, Bremen, and Dresden) to important functional locations in other metropolitan regions (e.g. Brunswick, Essen, Mainz, and Augsburg) to mid-size and smaller scientifically important locations that, as regiopoles, are of great importance for the corridors of development (e.g. Kiel, Bielefeld, Würzburg, and Freiburg) described in the following section.

2.3.2 Corridors of Development

Developmental options for the knowledge society also exist between metropolitan regions. These areas cover large parts of rural western Germany. In their spatial distribution they form corridors of development connecting metropolitan areas. In these corridors mid-sized and small cities form a chain of knowledge society nodes, and rural regions either develop into high technology regions or service centres that have infrastructures highly relevant to the knowledge society. Due to the spatial assemblage of these knowledge society clusters the structure of the regions becomes clear: large cities are at their core, urban centres between these cities have a complementary function as regiopoles, and rural areas strongly influenced by the knowledge society absorb all knowledge society based activities that the large centres, despite all their advantages, do not necessarily need.

For the purposes of communicating and spreading knowledge, physical and relational distance are determining factors in the knowledge society for the ability to share knowledge, initiate learning processes, create new insights, reduce insecurity, and plan common activities. Obviously, such conditions are not only found in large cities or the urban areas that surround them, but also occur in various forms and intensities in developmental corridors, especially in the regiopoles located within them.

2.3.3 New Periphery

The remaining part of Germany, which has a mainly rural character, is not entirely uncoupled from the knowledge society. However, such large deficits exist with regard to this type of society that in some cases the disparities between these areas and centres of knowledge society based activities may lead to a spatial polarisation that is difficult to resolve. Typical for this type of knowledge societal pattern is the limited number of companies related to the knowledge economy and a small amount of research activities. Thus, a private sector economy which supports knowledge society development is missing in these regions, as well as knowledge-intensive services and the high technology sector. Furthermore, large parts of the new periphery, especially in western Germany, are disadvantaged in terms of science and education.

These location specific disadvantages of the periphery are – if looked at positively – often associated with developments that are indirectly connected to the knowledge society, for example tourism, the health sector, and agriculture. So, this type of region can gain knowledge economy strength through links with knowledge society based cities in adjacent areas. If the partnership between knowledge society actors in cities and rural areas is successful, actors in rural areas will gain access to the knowledge society and, inversely, knowledge society based actors in the regiopoles will profit from an extended range of activity. When regional developmental concepts are successfully coordinated with local potentials and linked to neighbouring knowledge society centres, such regions can clearly distinguish themselves from residual regions that exhibit no or few relevant knowledge society based characteristics.

3 IMPLICATIONS FOR AN INTEGRATED TRANSNATIONAL CORRIDOR BETWEEN SCANDINAVIA AND THE ADRIATIC SEA

The previous explanations of observed spatial patterns point out that the development option of regions and cities to a great degree depends on how endogenous knowledge potentials could be linked with complementary knowledge potentials of other regions. This also results in a tendency for functional specialisation and collaboration to exploit potentials more efficiently.

These linkages or networks have a common functional content, which makes it necessary to consider the reconfiguration of space in the knowledge society not simply under traditional physical aspects. The special value of these functional networks for a territorial unit such as a metropolis, a rural district, or an urban region can only be exploited when these various knowledge worlds (knowledge spaces) are linked to one another. The resulting concentration illustrated in figure 2 explains the special knowledge society based suitability of agglomerations as well as the special profiles of some administrative districts in which pooling, when seen from a chronologic perspective, occurs around an established developmental path. Particularly important are transactions and their associated costs incurred by overcoming the barriers of communication and understanding that are crucial for the development of the knowledge society. These barriers are effective in a spatial sense – but in an institutional, as opposed to a physical, one.

Although these results are deviated from evidence of the German case it is reasonable to assume that such spatial patterns and phenomena also occur in other countries and macro-regions. For the particular case of the macro-region stretching from Scandinavia to the Adriatic Sea, no such analysis has been conducted so far. But the spatial picture, elaborated by Kujath et al. [1], seems to provide similar patterns (cf. figure 3). Economic, cultural, and knowledge nodes of this corridor are the metropolises and large cities as opposed to their hinterland, which in many cases falls behind considerably. The metropolises serve as centres of science, have an outstanding cultural function and attract knowledge intensive companies. But the macro-region is also characterised by a number of administrative and state boundaries resulting in various institutional settings and partially large institutional distances between locations in different countries. It is likely that these institutional boundaries hinder transnational-cooperation between cities and regions as well as companies, as the actual level of cooperation is relatively low.

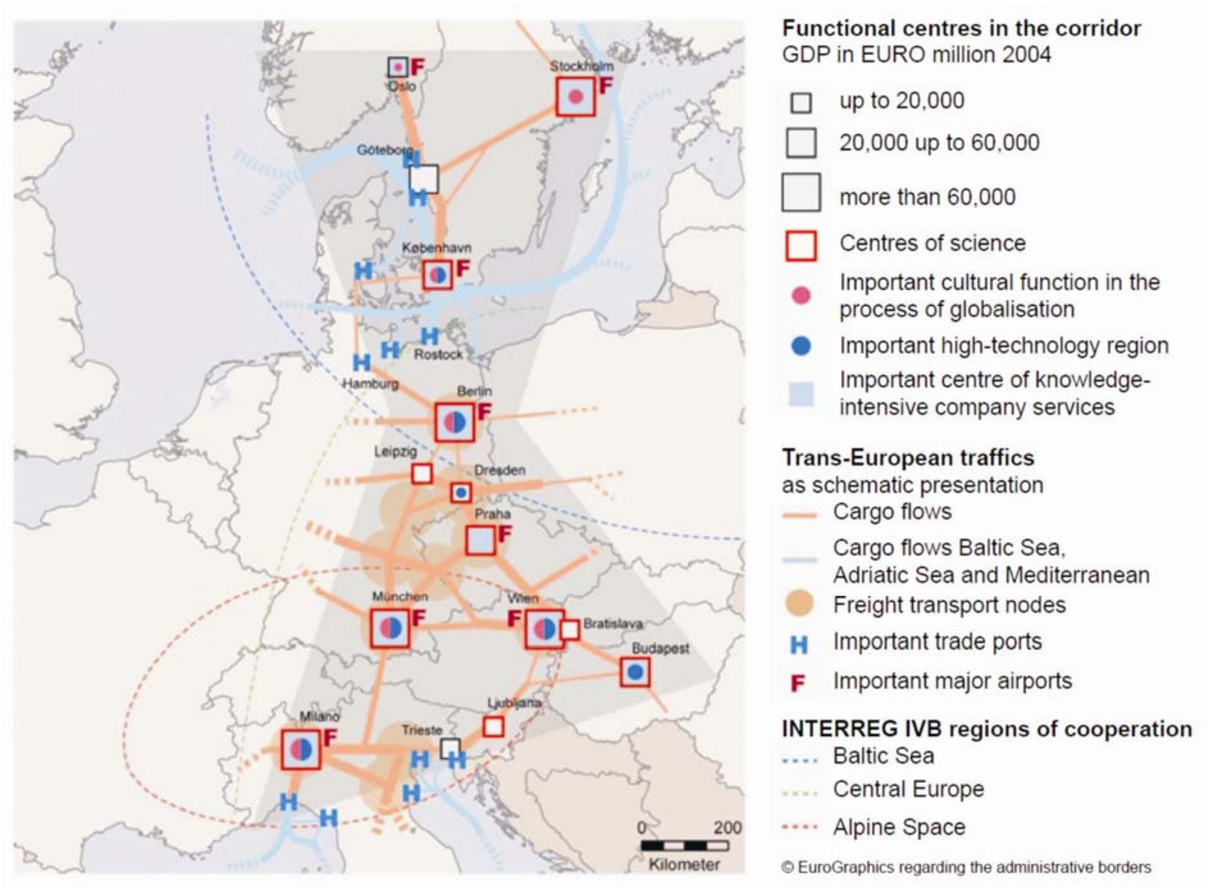

Figure 3: Territorial capital in the Baltic-Adriatic development corridor [1]

The case of the Baltic-Adriatic development corridor shows that special attention therefore needs to be given to the institutional arrangements (i.e., forms of governance) that are chosen by actors in order to reduce these transaction costs. More precisely, there seems to be a requirement for:

- regional scale horizontal cooperation through transnational city networks, urban-rural cooperation on a regional level, and development of a linkage between less knowledge society coined regions and regiopoles,
- development of a common understanding of the macro-region, supported by aligned rules to enhance cooperation activities,
- introduction of the corridor perspective into national/regional activities through alignment of both,

- development of institutional settings to reduce insecurities of various forms of distance.

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SYSTEM DYNAMICS IN TRANSPORTATION

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ABSTRACT

Different types of models have been in use for decades in order to describe transportation networks. These models make it possible to portray real systems using qualitative and quantitative parameters, therefore they can be examined. Conventional transportation simulation models are difficult to use in the case of complex systems as well as not or simply restrictedly containing data, which are necessary to describe the system. Urban transportation systems are often complex with many different types of parameters and their relationships. In certain cases, these systems can easily be described by system dynamics tools. This article introduces a system dynamics model, which is suitable for examining urban transport systems not at a deep level, like a transport simulation model, but since the number of necessary parameters is relatively fewer it makes its simple use possible without building a more complex model.

1 WHY WE NEED MODELS

In an engineering environment models are often made in order to better understand the real world and real life. With the help of these models, problems can be simplified and the simplified models provide an opportunity for the examination of these problems as well as for the analysis of emerging ideas which can be materialized. One must strive not to lose any information, which may be important later regarding the system as a whole and how it works, via the simplification.

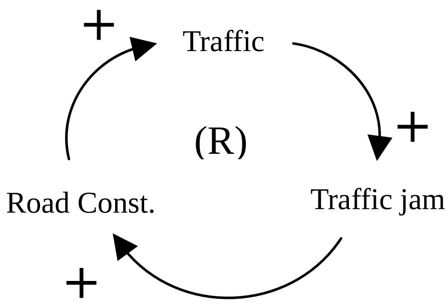

Figure 1: Causal-loop diagram

The description of complex systems presupposes relationships, which are based on each other, the portrayal and correct interpretation of which is important in order to understand the system. A system dynamics model describes the relationship between the individual elements of the system with the help of standard elements therefore it is suitable to solve the problem. Generally the verbal description of a system can be portrayed by a causal loop diagram. For example, nowadays traffic jams are getting to be a great problem. For a while a solution could be to build new roads but in a short while these roads also get congested. The causal loop diagram of the previous example can be seen in Figure 1.

If the outlined process is basically simplified, we then get the closed cycle in the diagram. But in real life this is not so, since many basic conditions (land use, financial situation) must be taken into consideration. A model is as precise as the number of basic conditions it is able to manage. Of course everything cannot be taken into consideration, it is the model maker's task to determine in a given case which elements and links are important that will decisively influence the functionality of the model.

The causal loop diagram can be two-directional, positive and negative. In the system dynamics literature, positive loops are sometimes called "reinforcing loops" and negative loops are sometimes called "balancing loops" or "counteracting loops."

Positive feedback processes destabilize systems and cause them to "run away" from their current position. Thus, they are responsible for the growth or decline of systems, although they can occasionally work to stabilize them.

Negative feedback loops, on the other hand, describe goal-seeking processes that generate actions aimed at moving a system toward, or keeping a system at, a desired state. Generally speaking, negative feedback processes stabilize systems, although they can occasionally destabilize them by causing them to oscillate.

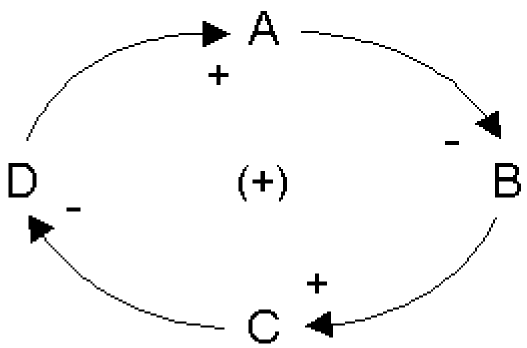

Figure 2: Positive causal-loop diagram

For example, if a shock were to suddenly raise Variable A in Figure 2, Variable B would fall (i.e. move in the opposite direction as Variable A), Variable C would fall (i.e. move in the same direction as Variable B), Variable D would rise (i.e. move in the opposite direction as Variable C), and Variable A would rise even further (i.e. move in the same direction as Variable D).

Dynamicists often use the letter "R" (for "Reinforcing") or an icon of a snowball rolling down a hill to indicate a positive loop. To indicate a negative loop, the letter "B" (for "Balancing") or an icon of a teeter-totter is used.

More specifically, some system dynamicists prefer to place the letter "S" (for Same direction) instead of a plus sign at the head of an arrow that defines a positive relationship between two variables [2].

2 PROBLEMS WITH CAUSAL LOOP DIAGRAMS

Causal loop diagrams are an important tool in the field of system dynamics modeling. Almost all system dynamicists use them and many system dynamics software packages support their creation and display.

Although some system dynamicists use causal loop diagrams for "brainstorming" and model creation, they are particularly helpful when used to present important ideas from a model that has already been created. The only potential problem with causal loop diagrams and archetypes then, occurs when a decision maker tries to use them, in lieu of simulation, to determine the dynamics of a system.

Causal loop diagrams are inherently weak because they do not distinguish between information flows and conserved (non-information) flows. As a result, they can blur direct causal relationships between flows and stocks. Further, it is impossible, in principle, to determine the behavior of a system solely from the polarity of its feedback loops, because stocks and flows create dynamic behavior, not feedback. Finally, since causal loop diagrams do not reveal a system's parameters, net rates, "hidden loops," or non-linear relationships, their usefulness as a tool for predicting and understanding dynamic behavior is further weakened. The conclusion is that simulation is essential if a decision maker is to gain a complete understanding of the dynamics of a system [2].

3 THE STRUCTURE OF A MODEL

As soon as the link diagram is available, thus the functionality of the model is described, the real examination and analysis can be done via some software. The software is not necessarily a system dynamics tool, since as you will see later in the article, in fact we are talking about solving equations so even a spreadsheet software can be used. Naturally the use of system dynamics software has several advantages regarding their manageability.

The causal loop diagram must be transformed for further use. Usually a Stock-Flow diagram is made, system dynamics models also portray systems in this way.

As it can be seen from its name, the diagram consists of two main elements:

- Stock: this is a stock element in which we set the elements in the model according to amount, quantity and value. Each and every element may contain its own individual characteristics.
- Flow: this is an element which affects flow. It regulates the flow of moving the content of stock elements from one to another taking into consideration the given parameters.

We can simply say that we record the starting amounts and values in the stock element, then the influence had on them will be given by the flow regulating elements. The process in Figure 1 can be portrayed by 2 stock and several flow elements. One of the stocks represent the number of roads, the other represents traffic. The flow regulating elements carry out the conditions. For example, if there is a traffic-free road, traffic may grow, if congestion has reached a certain level, a new road must be built, after which the result will be a traffic-free road and the cycle continues.

With the help of the flow regulating elements, an opportunity is made to use the values of time. The problem with these elements is that the longer the examined time interval, the greater the uncertainty of the value of the element.

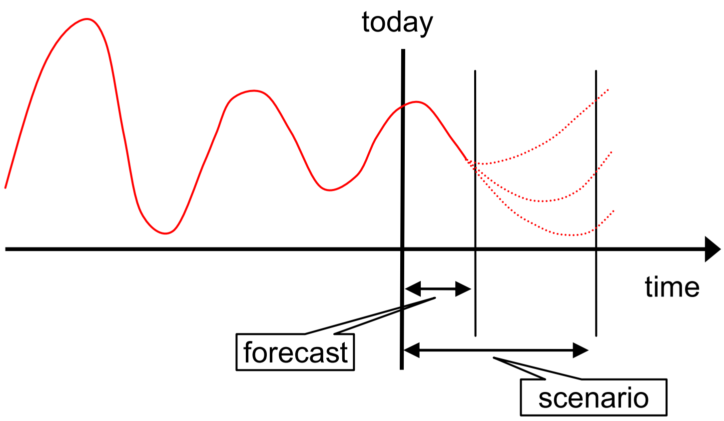

Figure 3: Forecast or scenario

We can talk about a forecast with some probability for a while due to the nature of the data, then it is only possible to create different variations. As can be seen in Figure 3., the inaccuracy of the parameters lead to very different results.

The general conclusion that the reader should draw from these graphs is that real systems often generate clearly identifiable time patterns and that system dynamic models can be built to mimic the patterns.

What is necessary for the effective use of system dynamics?

- a description of the problem
- the identification of important elements
- a causal-loop diagram
- a stock-flow diagram
- system dynamics software
- an analysis of the results

4 SYSTEM DYNAMICS IN TRANSPORTATION

If we consider real life, one can see that transportation plays a central role in our modern society. Its relationship to society, the environment and the economy is extremely close. We can create a causal loop from Figure 4 with a little abstraction in only seconds. Naturally, it is important to define the characteristics in a precise manner.

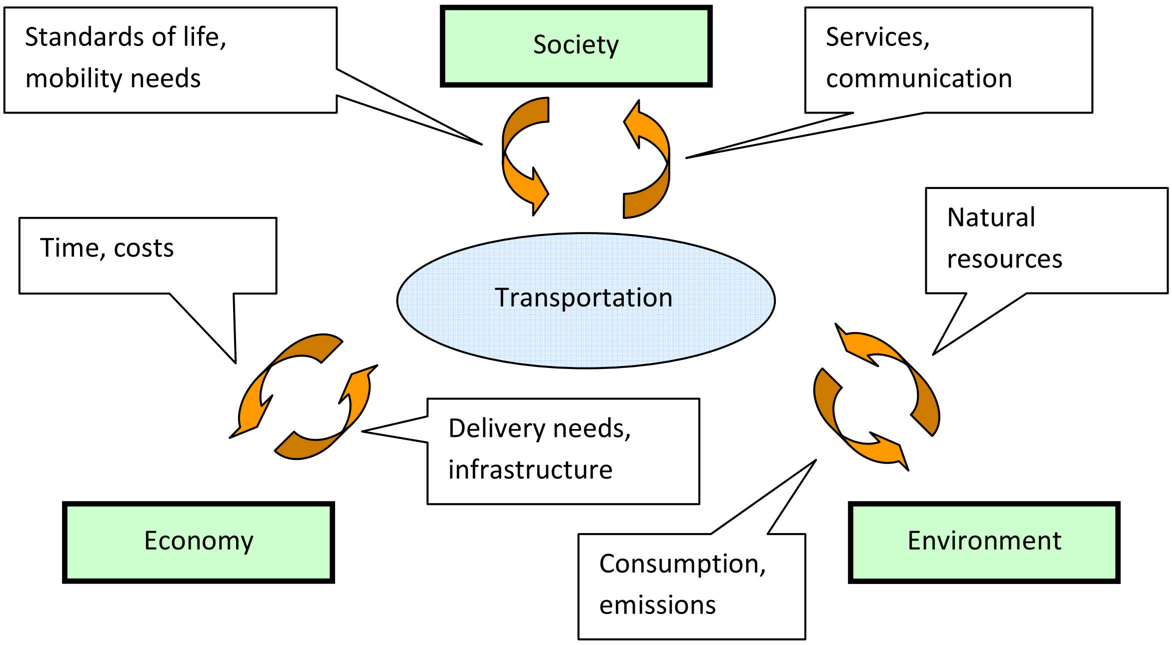

Figure 4: The links in transportation

The model made by Wang and Co [3] – the representation of Figure 4 – is a good example of how system dynamics can be used successfully in the case of transportation problems. One can easily observe the effects the different system elements have on each other. Mobility needs play a crucial role in the diagram. If we examine the flow chart, we can see that the elements of individual and public transport appear. However, an integral part of transportation is freight transport which constitutes a considerable part of its problems. A freight transport model can be built just as easily as one of passenger transport. If we want to use the model for the examination of urban development problems, then it has to be supplemented with the parameters related to land use.

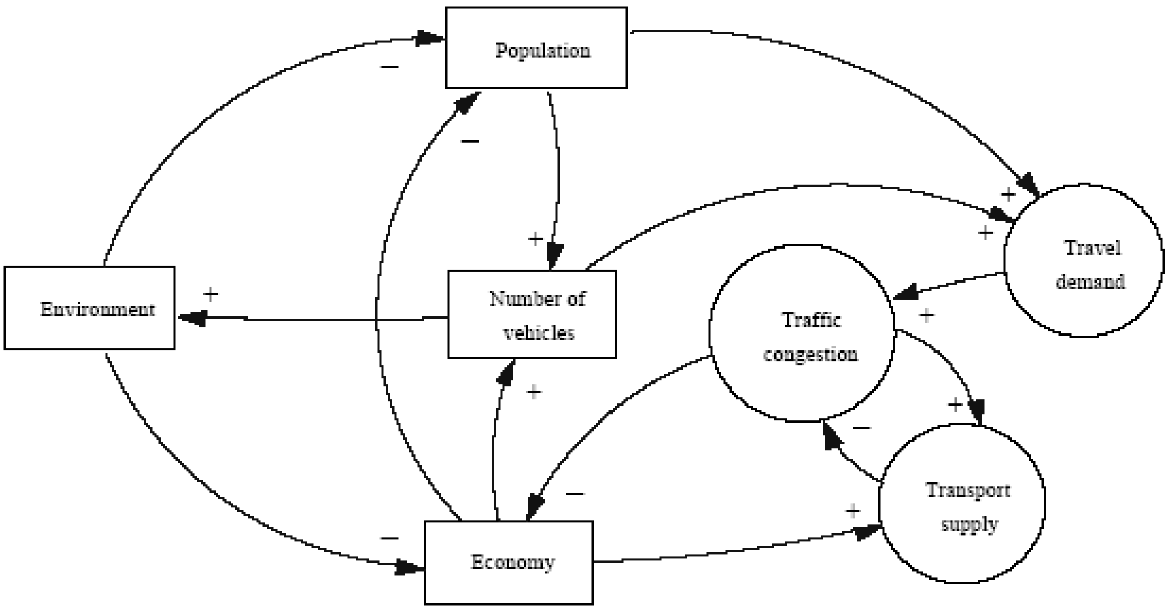

Figure 5: Relationships among sub-models [3]

The representation of the causal loop diagram in Figure 5 can be seen in Figure 6. The individual elements - stocks - and their flow element counterparts can easily be distinguished.

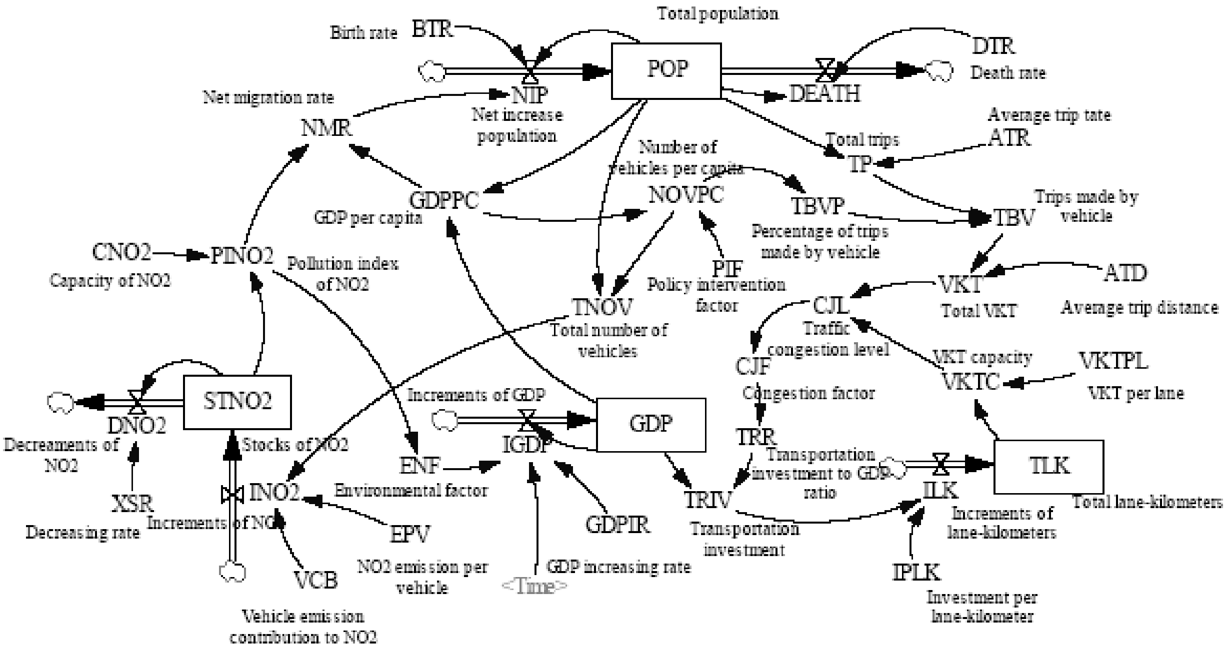

Figure 6: Flow chart of the urban transportation system [3]

5 CONCLUSION

System dynamics can be successfully utilized in the case of transport problems but it is important under what circumstances it is applied. As we have seen, a basic model can be expanded in many ways with the addition of further elements, therefore the area of utilization can be quite diverse. In my opinion though, system dynamics is rather a macro tool in the field of transportation. Nowadays, we can observe representations which are quite detailed. In the case of public transport, models try to deal with each and every passenger or every event separately. This, of course, has its price: complex and difficult to use models. In these cases, the collection of suitable data is often a problem. A good solution could be to have the usual simulation procedures work together with system dynamics. Using the model built with system dynamic tools, examination of how the system works can be accomplished and the results of this examination can be used in simulation models. The construction of a system dynamics model is relatively simpler, it can be used with less data although of course its results are not as detailed as in the case of the usual simulation models.

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CHANGING TRANSPORT ROUTES BY STRENGTHENING THE MEDITERRANEAN PORTS

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ABSTRACT

New sea ship routes and the extension of the Suez Channel will probably lead to an increase of intercontinental sea ships landing in Mediterranean ports. This will strengthen the Mediterranean ports but it also implies a change in hinterland transport strategies to serve European inland destinations.

The international railway sector has to face a batch of operational and managerial changes: Transportation lengths and times to the inland destinations will change significantly. Apart from administrative and technical barriers (railway facilities in ports, railway links), geographical conditions will also have a significant impact on railway operations and thus on land transport costs. To give an example, a locomotive class 145 may haul 3,000 t in northern European lowland regions; in mountainous regions this value may be halved.

New transports from southern ports to northern Europe may also have positive aspects: By using south-eastern ports, the congested tracks of Austria and Switzerland can be bypassed. Also, by a comprehensive division of northern and southern transport destinations, the freight transport crossing the Alps can be decreased and thus the sensitive nature will be preserved.

1 INTRODUCTION

Trade and consequently the transport of goods between regions has been a human issue since the ancient times. The desire for goods from other areas helped transport to become an important matter without the consideration of its economical aspects. With trade, prominent transport routes have been developed. Many of them still exist. They connect distant markets and places, especially port cities.

Nowadays transport is more than the movement of goods. It is a business that serves other branches and it influences among others the division of labour and the local specialisation on the production of certain goods. Modern freight transport is rather denominated by the word logistics and is a dynamic and changing affair. With the growth of freight transport volumes and the technical development the old trade routes changed. Land side routes became less important and have been replaced by routes through the oceans because the transport by sea ship allowed carrying higher amounts at once with reduced shipping costs (economies of scale).

In Europe, mainly the cities at the Atlantic and the North Sea coast emerged as intercontinental trade centres with connections to Asia and America. The distribution of transport flows within the European continent took and takes place by land and river transport. Economic issues drive logistics regularly to improve transport routes and thus mainly to shorten and/or accelerate them. Examining intercontinental shipping routes, one emerging issue of our days is the exploration of alternative trade lanes between Asia and

Europe. This route, with a share of 8.2%[2] of the world trade flow, is an important backbone for international logistics. One possibility to shorten and accelerate this shipping route is sailing through the Suez Canal instead of circumnavigating Africa. Currently not all modern sea ships are eligible to pass the canal but extension works are already in progress so that the biggest at present existing container ships are able to go through it.

Using the Suez Canal and thereby crossing the Mediterranean Sea offers chances for the southern European countries and their ports. Right now these ports serve mainly regional markets or act as hubs. The outstanding majority of maritime container traffic is handled in northern European ports. By attracting shares of this container traffic, an enormous potential can be seen in southern ports.

The achievement whether it is possible to pull maritime cargo flows to southern European ports is not only the case of extending their capacities and the installation of modern transhipment technologies. The success depends highly on the conditions of hinterland connections.

Because it is beyond all questions that inland transport generates the highest costs in intercontinental transport chains, an efficient hinterland connection from and to the southern European ports is one of the key issues that may lead to a pull of cargo flows towards the southern ports. In European hinterland traffic rail freight haulage has a fundamental fraction and is seen as an efficient and rather environmental friendly transport mode. Consequently the question is, what the European railway sector is to encounter.

2 CONTAINER FLOWS IN EUROPE

Decisions on transport routes are generally made on an economic basis. The crucial factor is the capital employed during the transport processes. In intercontinental transport chains the highest costs occur in pre- and on-carriage. The sea routes have comparably low costs. Nevertheless the decision about pre- and on-carriage is subordinated to the sea route. Gigantic modern container ships call only at certain ports where the transhipment processes are fast and thus the holding time (an idle period) is short. The further distribution of cargo flows is organised as a second step.

To give an overview over the current hinterland cargo flows in Europe, continental container flows can be regarded. The flows with the highest traffic are oriented in a strong vertical way. With figure 1 the Top 10 of the European international flows of combined transport is shown.

[2] Share of eastbound and westbound trade flows in world merchandise exports according to the WTO International Trade Statistics 2009 [see 5]

Origin	Destination	Consignments
IT	DE	305.404
DE	IT	298.085
BE	IT	93.657
IT	BE	85.353
AT	DE	74.920
DE	PL	65.019
DE	AT	49.967
AT	IT	46.937
NL	IT	46.700
PL	DE	40.161

Figure 1: European Top 10 cargo flows in combined transport, based on data of the UIRR [3]

From these cargo flows only the relation AT-IT can be regarded as a southern-only flow while the others contain a significant share of transports from the northern European ports to southern Europe and vice versa. The relations DE-PL and PL-DE on the contrary are a typical east west trade route and can be seen as the first exception among the intense cargo flows.

Studying the pan-European transport flows, it has to be asked whether an inland transport in north–south direction is efficient if the origin/destination of a good is closer to a southern European port. The answer to this question is subject to two constraints, as said at the beginning:

a) Container ships call only at certain ports and

b) The inland connection to and from the port is a critical bottleneck.

To estimate the potentials of the southern European seaports these two issues are the focus in the following sections.

3 DEVELOPMENT OF SOUTHERN EUROPEAN PORTS

The northern seaports have an advance in development of several decades and thus their capability is, needless to say, higher than the one of the Mediterranean ports. Steadily growing container ships put pressure on the ports because a ship's holding time is to be minimised. This led the terminals expand and modernise their facilities so that nowadays the bottleneck moved to the downstream sector of the transport chain – the hinterland connection. Modern container terminals, as Hamburg Altenwerder can output more units than the hinterland connection is able to absorb. Taking into account that a significant share of hinterland traffic is handled by rail but also the improvement of railway capacities is a long-term action, it is clear that there are limits in the current freight transportation system.

Provided that the economic growth worldwide will increase, there is a possibility to shift transports from the northern to the Mediterranean ports and thus to avoid long and unreliable transports through Europe. Right now, noteworthy disparities exist in the conditions of the Mediterranean ports, in particular in waterways, quayside capacities, transhipment technologies, handling capacities as well as land-side access connections. A former research, shown in table 1, has determined the railway facilities of European ports with a differentiation between northern and southern ports. Also there, the quintessence is that the southern European ports have a lot of catching up to do to compete with northern European connections.

Port	Railway Facilities (1=poor, 5=excellent)	Main Handling Equipment for Railway	Annual Volume TEU (2008)
Rotterdam	5	Gantry Cranes	10.5
Hamburg	5	Gantry Cranes	9.8
Antwerp	5	Gantry Cranes	8.0
Bremerhaven	4	Straddle Carriers	5.0
Zeebrugge	4	Gantry Cranes	1.4
Gdynia	4	Gantry Cranes	0.5
Amsterdam	3	Gantry Cranes	0.4
Lübeck	4	Gantry Cranes	0.3
Szczecin	3	Straddle Carriers	0.05
Genova	3	Gantry Cranes	1.6
La Spezia	2	Gantry Cranes	1.3
Marseille	2	Straddle Carriers	1.0
Venice	2	Gantry Cranes	0.3
Koper	3	Gantry Cranes	0.3
Trieste	3	Reach Stackers	0.2
Ravenna	2	Gantry Cranes	0.2
Ancona	2	Gantry Cranes	0.1
Rijeka	1	Reach Stackers	0.1

Table 1: Comparison of European port's railway facilities, source: [8]

All ports at the Mediterranean Sea have more or less concrete plans for their enlargement and development. Their main aim is to increase the capacities on the waterfront. Studying the investment plans of the ports shows, the focus is on actions like the build-up of modern terminals, improvement of the seaside connection, and the creation of logistic centres. Land-side access is not their focus and seems to be underestimated. Only the bigger institutions among them consider hinterland access and in particular railway connections as a competitive factor.

4 THE IMPACT ON EUROPEAN RAILWAYS

Taking into account that the Mediterranean ports will attract more intercontinental container ship traffic, their sphere of activity will expand both, sea sided and land sided. The landing of larger ships leads to economies of scale also on hinterland connections because the dispersion of goods in space decreases. More goods are to be forwarded between the port and a certain inland destination. This aspect intensifies even more by the use hinterland hubs. Besides, it supports an advantage of railway transportation – the haulage of large masses.

The railway branch is known to be rather conservative and slow developing. The cause can be seen in the mostly big railway operating companies with a certain market power on the one hand and with a lack of action according to changes on the other hand. Whether the European railway market is capable to face the possible changes can be determined with the help of several parameters. In a short preliminary enquiry some parameters have been compared to estimate the impact of changing transport routes on railway operations.

In the preliminary enquiry the aim was to forward a container block train from a port to these destinations: Vienna, Zürich, Prague, Brno, Munich, Leipzig, Paris, Lyon, Budapest, Bologna, Kraków, Poznań, Ljubljana and Bratislava. It was to find out, whether an access from an Atlantic or a Mediterranean port is more effective.

4.1 Infrastructural Constraints

The infrastructure is, certainly, one of the critical parts of the railway system. In comparison with road transport a series of constraints have to be regarded, e.g. the succession of trains, special safety standards or operational procedures just to state a few of them. In the countries of Europe the railway systems have been developed rather as national systems. Not only gauges differ. Also, safety and signalling systems or power supplies vary. Nowadays, having regard to international transports, this fact emerges as one of the big disadvantages in railway transportation and requires an enormous administrative expense. Border crossings and the tracks to them are often a bottleneck that decreases the speed to 15-20 km/h [see 7]. Especially the railway systems in smaller countries are affected to be isolated.

4.1.1 Railway Infrastructure Conditions

Regarding the development of railway infrastructure, it becomes clear, that the conditions in southern and eastern Europe differ from them in northern Europe. With the view on hinterland access the northern railway network is more capable to withstand the high loads of seaport-inland transports. Good infrastructure conditions can be found in the Benelux and Germany but also in the Alp's region of Austria and Switzerland as well as in the Italian network. Nonetheless the main freight corridors in these regions suffer from congestion and overload. Many tracks of important north-south relations have a workload of more than 100% as shown in figure 2. A theoretical workload of 65-80% is considered to be manageable. Eastern European railway tracks are less congested but suffer from general low capacity and bad conditions. Main obstacles are development conditions. Lines are often single-tracked, not continuous and not electrified. Results are permanent shunting, changing of locomotives or the use of diesel engines. Those obstacles let rail transport become slow and expensive and thus it is not attractive for logistic service providers.

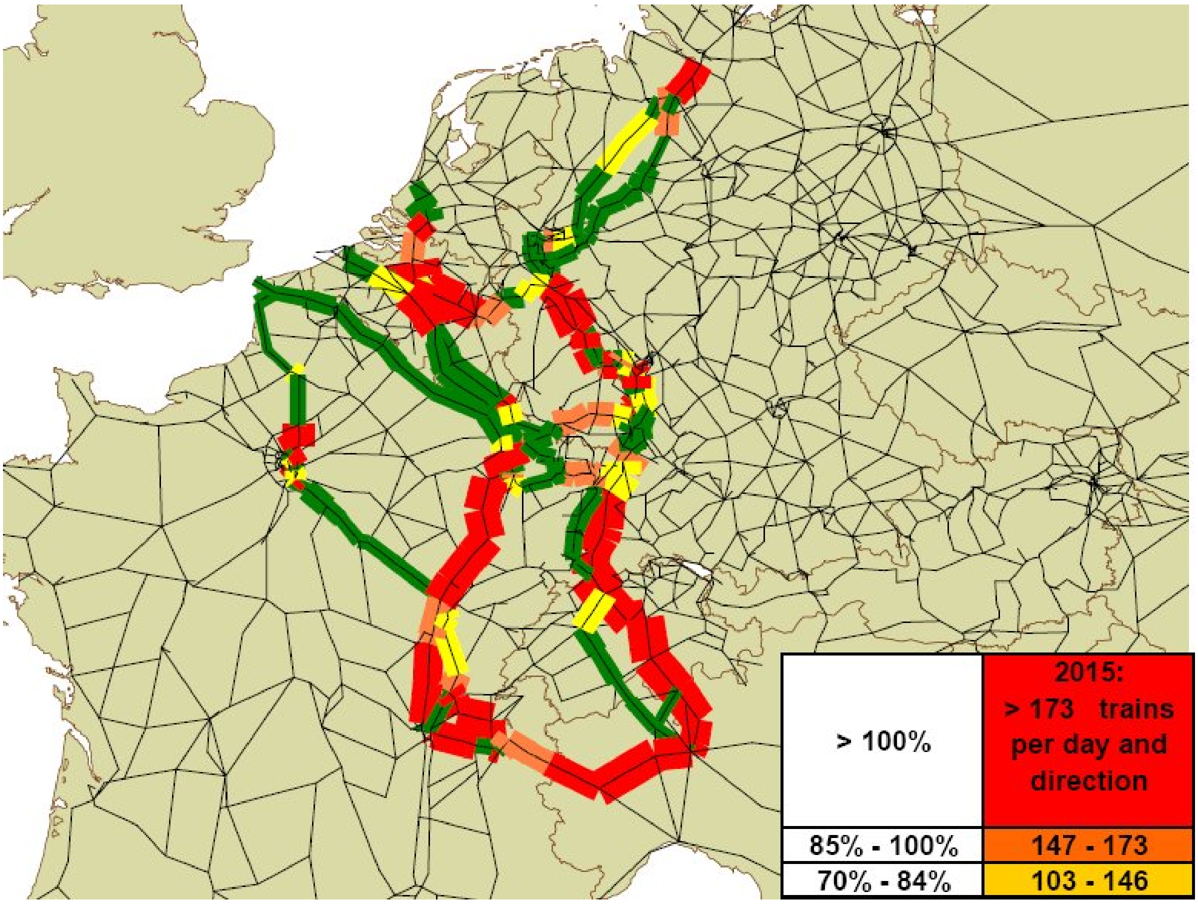

Figure 2: Utilisation of today's railway capacity in the year 2015 in Benelux, France, Germany, Switzerland, Italy, source: [1]

For a fast rail freight hinterland connection, the only suitable solution is a double-tracked (unidirectional operation) electrified line to supply the seaport. Table 2 shows the share of those relevant lines for each of the regarded countries. It denotes the low infrastructure conditions especially in the Czech Republic, Hungary, Slovakia and Slovenia where less than one third of the railway network is equipped with double-tracked, electrified lines. On the other hand there are Belgium and the Netherlands with a share of more than 70%.

at	be	ch	cz	de	fr	hu	it	nl	pl	si	sk
33%	73%	99%	18%	40%	41%	16%	39%	79%	39%	27%	25%

Table 2: Share of double-tracked lines in the railway network by country, source: [6]

4.1.2 Railway Infrastructure Technologies

A second obstacle for efficient rail freight logistics are the miscellaneous infrastructure and signalling technologies installed over Europe as illustrated in figure 3. Freight cars are eligible to run on most of the European tracks – gauges and track clearances are mostly not the issue. The problem affects mainly locomotives whose radius of action is restricted. Modern engines are able to operate in several countries but there exist only a few for now. They have to be equipped with several energy and safety systems and must be approved by the correspondent country's authority. The double equipment decreases the cost-benefit-ratio of the locomotives noticeable.

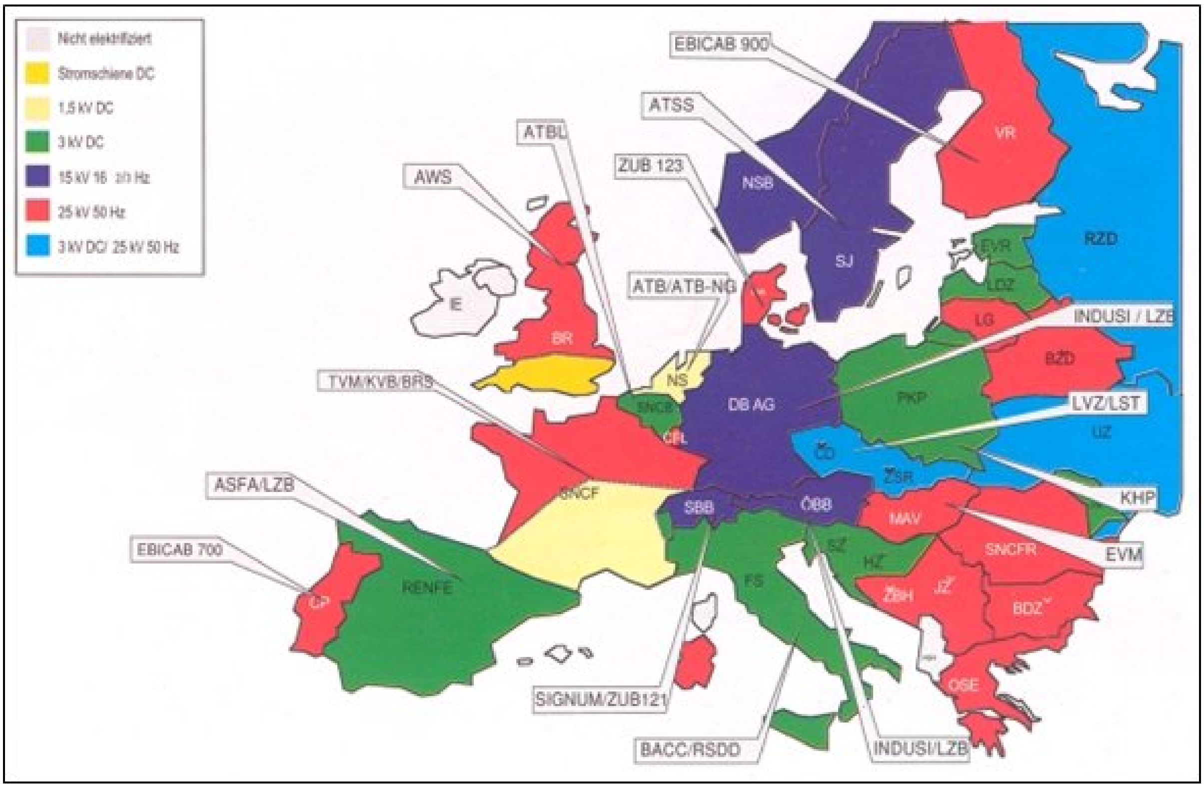

Figure 3: Power supply and train protection systems in Europe, source: [4]

Changing a locomotive at borders is not a technical problem but one for the flow of logistic processes. The Changing is connected with some railway specific operations. First, an additional stop is required. Second, the need of a suitable engine at the right time is self-evident as well as a new assignment for the now free engine. Deadhead trips are to be avoided. What is more, with the new train configuration a brake test is instructed which needs between 15 and 45 minutes according to country specific rules and the type of train. Under these circumstances a loss of one hour for the transport is possible.

4.1.3 Geographical Constraints

Another limit for rail freight transport is the earth's surface. Due to peaks heavy freight trains cannot have the full length and consequently economies of scale drop. The train length is important for the economic success of a railway operator. Too short trains are not profitable in the long term.

As an example in figure 4 illustrates, the traction of locomotives abates in hilly regions. In the example a container train loaded with units of 40 tons each and hauled by a class 145 engine has been used. In lowland regions the capacity was limited only by the allowed train length. In highland regions it was cut up to 40%.

The northern European area has some advantages according to its geography. High capacity freight trains are feasible with little effort. In middle and southern Europe trains with a comparable load are more difficult to realise. They can be set up by using for example two locomotives, which is rarely done in central European railway operation.

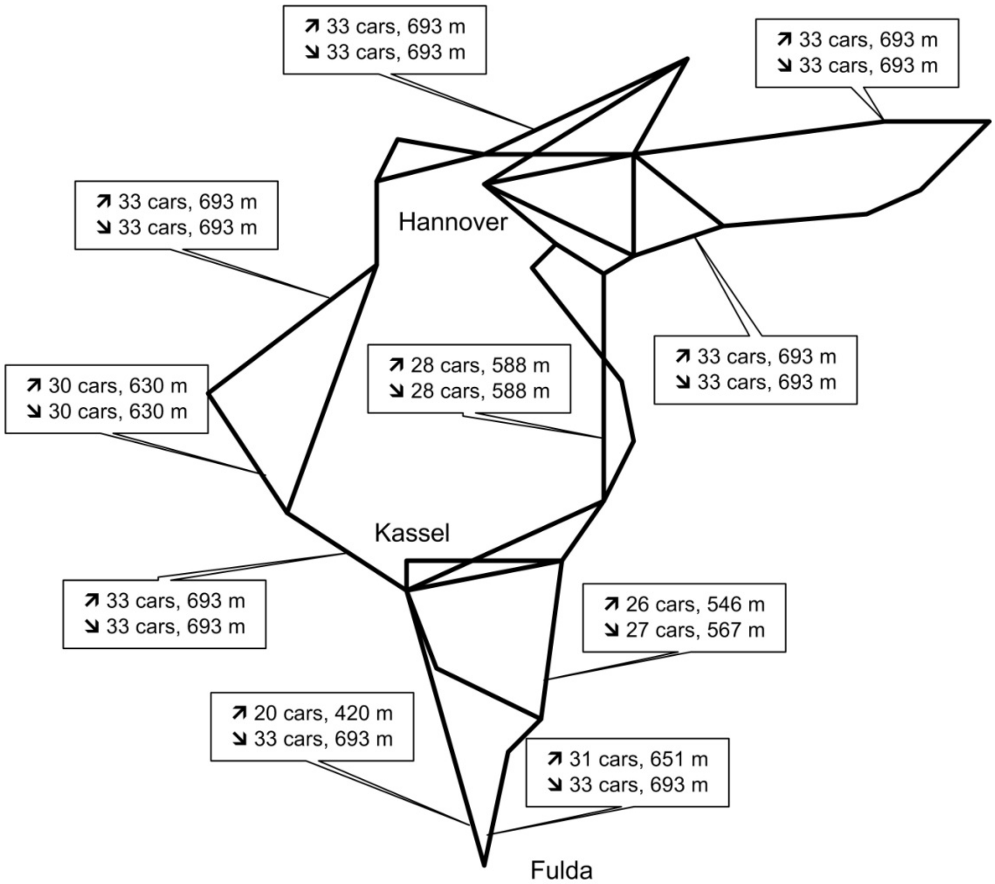

Figure 4: Load limits for container trains with Sgjns(s) cars and a class 145 locomotive in a section of the German rail network. The numbers show the maximum of loaded cars per train and hence the maximum train length for uphill and downhill runs with respect to the engine traction. Own elaboration using data from [2]

4.2 Managerial Constrains

Besides the technical issues also managerial constraints appear in international railway logistics. As already mentioned the allowed train length is limited and narrows the train's capacity. Very often the maximum length is 700 m but some countries have lower restrictions, e.g. Belgium: 600 m, Italy: 550 m.

A challenging managerial issue is the organisation of train paths for international transports. By hauling through several countries, for each network it is necessary to book a train path at the local or national railway infrastructure operator. The neighbouring single train paths should match concerning the time. Otherwise additional time losses occur.

As mentioned in 4.1.2, the organisation of locomotives at borders is also a managerial constraint. With it, the driver has to be organised, too. His working hours have to be regarded, but also he must be eligible to drive the certain type of locomotive and he must be eligible to drive on the certain route because the knowledge of the tracks is instructed. As a result, hauling freight trains through many countries raises the costs of operation.

5 RESULTS AND CONCLUSIONS

For the regarded European inland destinations it has been examined, whether a seaport access to northern or southern ports is favourably. For it, the characterized operational and managerial constraints have been evaluated. The results, concentrated in table 3, show that under the current circumstances for the most regions an access to and from northern ports is more suitable. With the harmonisation of the infrastructural differences in the regions of Europe this might change. The technical and managerial constraints may remain or are at least more difficult to decrease.

For efficient logistics the hinterland connection is important and a capable railway connection is one of the key issues there. Without a capable hinterland connection southern European seaports will remain only as transhipment hubs where they increasingly compete with African ports that already started to invest big amounts to offer similar services.

To offer competitive rail freight services to and from seaports, a smoother movement of freight trains across Europe, in particular in international transport, is needed. This applies for the northern but even more for southern ports. More market oriented planning and action is needed to swap freight transports to southern Europe. With a harmonised railway system in southern and eastern Europe probably long north-south traffic can be avoided and thus transport chains and transport time shortened, as illustrated in figure 5. As a result the costs on expensive pre- and on-carriage routes decrease.

Vienna	**Zürich**	**Prague**	**Brno**	**Munich**	**Leipzig**	**Paris**
favourable northern European ports and evaluation						
Hamburg, Rotterdam	Rotterdam	Hamburg	Hamburg	Hamburg	Hamburg	Le Havre
3.1	3.6	2.5	2.8	2.7	1.5	1.7
favourable southern European ports and evaluation						
Trieste, Koper, Rijeka	Genoa	Trieste, Koper, Rijeka	Trieste, Koper, Rijeka	Venice	Venice	Marseille
3.5	4.3	5.0	4.4	4.1	4.1	2.1

Lyon	**Budapest**	**Bologna**	**Kraków**	**Poznań**	**Ljubljana**	**Bratislava**
favourable northern European ports and evaluation						
Le Havre	Hamburg	Antwerp	Hamburg	Hamburg	Antwerp, Hamburg	Hamburg, Rotterdam
2.3	3.6	4.7	3.0	2.0	5.0	3.9
favourable southern European ports and evaluation						
Marseille	Rijeka	Venice	Trieste, Koper, Rijeka	Trieste, Koper, Rijeka	Trieste, Koper, Rijeka	Trieste, Koper, Rijeka
2.3	4.1	2.0	4.9	4.8	3.5	4.0

Table 3: Preliminary enquiry of northern and southern European port access. Evaluation of operational and managerial constraints for selected cities according to their accessibility by railway from and to seaports. Rating 1=excellent, 5=poor.

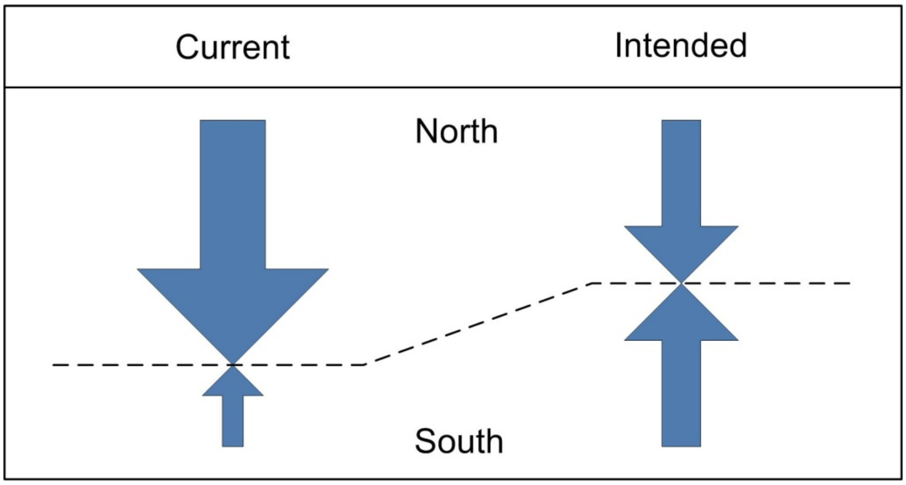

Figure 5: Intension to swap hinterland freight transports from northern to southern Europe to shorten transport chains.

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RELATIVE IMPORTANCE OF TRANSPORT INFRASTRUCTURE INVESTMENTS FOR ECONOMIC GROWTH

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ABSTRACT

The paper is based on a comprehensive literature review regarding the macroeconomic effects of transport infrastructure investments on economic growth. The literature supports the hypothesis that the macroeconomic effects of transport infrastructure investment significantly depend on the level of infrastructure endowment relative to the gross domestic product of a region. However, none of the authors so far has explicitly defined such a relationship. An attempt for a formal definition of the relationship is presented.

1 INTRODUCTION

The links between transport infrastructure investment and economic growth have been studied by several authors over decades. In general, economists agree that there is a positive correlation between transport infrastructure investment and economic growth, but the results of the relevant studies are often controversial. The purpose of this paper is to emphasize that the marginal productivity of investment in transportation infrastructure heavily depends upon the level of economic development of a country. There is considerable evidence that transport infrastructure investment is most productive in the more mature developing economies. Conversely, transport infrastructure exhibits lower marginal products in highly developed economies as well as in the least developed ones. Taking this into consideration the results of several studies become more comprehensible.

2 PROBLEMS WITH THE MEASUREMENT OF THE EFFECTS OF TRANSPORT INFRASTRUCTURE INVESTMENT ON ECONOMIC GROWTH

The fundamental problems of the authors of the studies dealing with transport infrastructure investments and economic growth are connected with the availability of the needed data and its reliability. Another problem is connected with the possibility of testing of the results. We are not in a position to establish the ‘anti monde’, that is the assessment of the economic development that would have occurred without the investment in transport infrastructure. There is also uncertainty about the direction of the impact of new transport infrastructure on the regions or nations affected. As transport infrastructure reduces the cost of both imports and exports of goods and services, the net effect is often not clear.

Macroeconomic research gives only indications about the demand and supply effects of bundles of historical investments in transport infrastructure. For the estimation various more or less sophisticated econometrics models are applied showing the causality of implied variables by the estimations. Moreover, macro research has only limited value when taking decisions on specific infrastructure projects. Surveys among regions and specific investment projects have various measurement problems, but they also have the advantage of providing ex ante micro information. Among the major disadvantages are strategic answers, sample selection and the inability to capture indirect effects on non-using stakeholders [13].

Already Kindleberger [11] suggested that there is no agreement on how economic development proceeds and he implied that this is because the process is not simple. There are many variables involved, and there is a wide range of substitutability among ingredients - land, capital, and the quality and quantity of labour, and technology can substitute for one another, above certain minima, although there are at the same time certain complementary relationships among them. The will to economise and organisation are probably the only indispensable ingredients. For the rest, none are necessary, and none sufficient.

The interest in the topic, though, is not purely an academic matter; public concern with regional disparities in economic performance and the considerable differences in national economic prosperity between the 'North' and the 'South' has brought forth efforts to stimulate growth in lagging economies by investing in various forms of infrastructure. The form and scale such measures should take, and indeed their general desirability, are matters of practical interest. In consequence, while Kindleberger is still correct in that our knowledge is in many respect very limited, efforts to clarify the situation continue [7].

3 TRANSPORT INFRASTRUCTURE INVESTMENTS AND ECONOMIC GROWTH

Economic development is generally seen as a complex process with transport permitting the exploitation of the resources and talents of a country; it is, therefore, necessary but not sufficient for development. Conceptually, economic development can be defined as:

- Enhanced individuals' utility from increase in the aggregate quantity of goods and services they consume and from a larger variety of these goods and services available in the economy.
- The annual rate of increase in the per capita level of output (for measurement purposes).
- Enhanced productivity of input factors.

Quigley [14] notes that these consumption and production definitions are analogous relative to the underlying conditions necessary for increased utility or aggregate output [4]

Given these definitions, the question is how to model the relationships between public infrastructure development and economic growth in order to ascertain empirically the degree to which the former affects the latter [4].

The causality interrelationships between infrastructure investment and economic growth are based on two fundamental premises:

- infrastructure capital expansion increases the efficiency and profitability of the business sector;
- this increase stimulates business investment in private capital [1][2].

Infrastructure can be viewed conceptually as an unpaid factor of production, which works through the production function by making labour and other capital more efficient. Much of the existing empirical literature on the linkage between infrastructure and economic growth seeks to capture this effect through observation of the relationship between increases in the stock of infrastructure (measured indirectly through public capital expenditure) and some measure of growth in aggregate output or productivity.

A review paper by Munnell [12] shows that there has been some interesting consistency among several of these studies in the estimated output elasticity of public capital. The coefficients are larger for the studies at the national level than at the regional level, and lowest at the metropolitan level of impact; this is explained by the ability of more aggregated studies to capture the indirect effects ("externalities") of infrastructure investments on various aspects of the economy.

Many of the findings from the mentioned studies have demonstrated positive and statistically significant relationships between public capital and output, but the conclusions have been often heavily debated [10].

Broadly, transport may be seen to have four functions in assisting economic development [9]:

- It is a factor input into the production process permitting goods and people to be transferred between and within production and consumption centres. Important part of this movement is between rural and urban areas so it permits the extension of the money economy into the agricultural sector.
- Transport improvements can shift production possibility functions by altering factor costs and, especially, it reduces the levels of inventory tied up in the production process.
- Mobility is increased permitting factors of production, especially labour, to be transferred to places where they may be employed most productively.
- Transport also increases the welfare of individuals, by extending the range of social facilities to them, and also provides superior public goods such as greater social cohesion and increased national defence.

Positive linkages between transport provision and economic development can be divided between the direct transport input and indirect, including multiplier, effects. Good transport offers low shipping costs which have permitted wider markets to be served and the exploitation of large-scale production in an extensive range of activities [7].

The indirect effects stem from the employment created in the construction of transport infrastructure and the jobs associated with operating the transport services. Further, there may be multiplier effects stemming from the substantial inputs of raw materials required to construct a modern transport infrastructure. Transport also often provided some initial experience of business for many industrialists of the period.

The overview of the direct and indirect effects of the transport infrastructure development and economic growth is presented at the (figure 1) below.

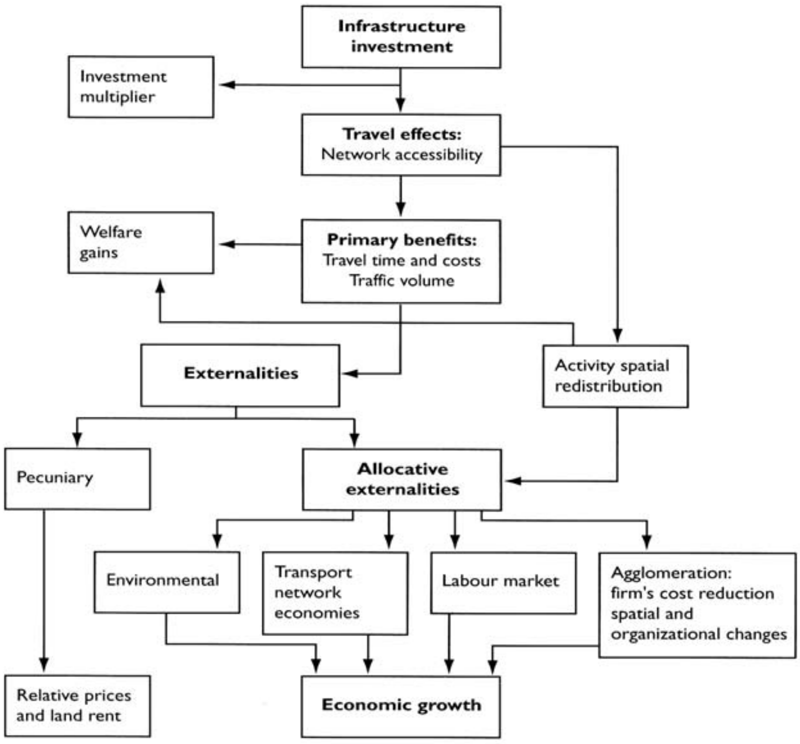

Figure 1: Scheme for the evaluation of economic growth benefits from transportation infrastructure investment [4]

Basically, transport can release working capital from one area which can be used more productively as fixed capital elsewhere, although a necessary prior condition is the existence of suitable productive opportunities in potential markets.

Looked at from a slightly different perspective, improved transport can help overcome bottlenecks in production and thus further foster economic expansion [5][16]. A difficulty, of course, if this true is that the bottleneck may be some distance from the region and superficially appear unconnected with it. Accepting this caveat, the basic view of this school of thought, whereby transport is seen more as a facilitator than a generator of development, is usefully summarised by [1]

While the approaches sketched out above describe a positive role to transport infrastructure in economic development, albeit in different ways, there is a feeling among some economists that an excessive amount of scarce resources sometimes tend to be devoted to transport improvements. As with any scarce input it is possible to define an optimal provision of transport to facilitate development so that resources are not wasted by being drawn from other activities where they may be more productive. At a given point in economic development, a country requires a certain level of transport provision so that its growth potential is maximised - hence there is an optimum transport capacity for any development level. It has been argued, however, that there are economic forces that tend to lead to an excess of transport provision (especially high cost infrastructure) at the expense of more efficient and productive projects [7].

At the macroeconomic level economists have pointed to the general influence that appropriate transport planning can have in assisting overall economic development. While it may be argued that ideally one should expand transport provision to balance developments elsewhere in the economy, this is not always possible. The balanced growth approach maintains that if transport services are inadequate, then bottlenecks in the economy will curtail the growth process, but if the services are excessive this is both wasteful, in the sense that idle resources could be earning a positive return elsewhere in the economy, and can become demoralising if the anticipated demand for transport does not materialise relatively quickly. Hirschman [18] takes a somewhat different view, arguing that the relationship between economic development and the provision of social overhead capital, such as transport, is less flexible than members of the balanced growth school believe [7].

4 EVIDENCE REGARDING THE RELATIVE IMPORTANCE OF TRANSPORT INFRASTRUCTURE INVESTMENTS FOR ECONOMIC GROWTH

It has already been argued in quite a few papers that the social returns of transport infrastructure investment depend on the level of economic development of a country or region. We have found different formulations of this idea in Canning and Fay [8], Rephann [15], Button [6], Oosterhaven and Knapp [13] and in Banister and Berechman [4]; the latter also draw a clear distinction between the roles of transport infrastructure investment in developing countries as opposed to developed countries. However, we have not come across a formulation of a hypothesis regarding the relative importance of transport infrastructure investment for economic development.

In this section, we postulate that there is a distinct relationship between the social returns on transport infrastructure investment and the level of economic development of a region (or country) and it seems to us that there is enough evidence available in the relevant literature to support this idea.

The central piece of evidence for our case stems from the work of Canning and Fay [8] who conducted one of the most carefully designed macroeconomic studies on the effects of transportation investment on economic growth. They perform a detailed analysis of panel data for 96 countries for the period 1960-1985 taken at 5-year intervals using the production function approach [10]. They use physical measures of transportation networks, kilometres of paved roads and railways, to estimate returns in the form of higher aggregate output, and relate these returns to construction costs.

Their findings point to a strong cross sectional positive dependence between output levels and the amount of transportation infrastructure in a country. On the other hand, they find no confirmation that increases in infrastructure lead to immediate increases in output. They settle these results by using a dynamic specification, which shows that "*the effect of infrastructure construction on output is slow in coming, but long lived*." Furthermore, they provide evidence that the main role of infrastructure investment is through promoting total factor productivity growth. They therefore argue that *"infrastructure capital should not be regarded as a normal factor of production, which directly produces output, but as a condition for high rates of economic growth.*

In the second step of their study, they take the coefficient of infrastructure estimated in the structural growth regression and compute the elasticity of output to infrastructure. The computed elasticity coefficient is equal to 0.0695, which implies a marginal product of transportation infrastructure of 0.0695 times Y/R, where Y/R stands for the ratio of GDP to infrastructure stock measured in kilometres. Using this formula, they compute the marginal product of infrastructure for 75 countries, based on data for 1985. Dividing the obtained values by the costs for the construction of a km of roads for each country, they obtain country-specific social rates of return.

Their results show that there is a distinction between mature economies that exhibit rates of return between 5% and 25% per annum, and economies which have reached maturity more recently where rates of return vary around 40-50% per annum. The highest rates of return, (in excess of 200%) are to be found in poorer, newly industrializing economies. In less developed, predominantly agricultural countries, they find rates of return of less than 50% a year. However, as the authors point out themselves, the data on the costs for the construction of a km of roads suffer from many problems. Therefore, we believe these rates of returned should be interpreted with caution.

Additionally, the authors divide the sample of countries on low, middle and high income countries and test if the estimated coefficient for infrastructure investment is robust across the sample. By performing the Wald test, they find that "*it is possible to reject the hypothesis of equality of the coefficient at the 1 % confidence level*." However, "*while the coefficient on infrastructure appears to increase with the level of income, the differences are not large compared to the standard errors*". They interpret these results in the following way: *"The results … suggest that the effect of infrastructure may be strongest in middle and high income countries and less pronounced in low income countries. This might lead us to suspect that the rates of return in the poorest countries, such as India and Pakistan, are somewhat lower than the figures we have reported. However, attempts to include an interactive term, allowing the infrastructure effect to vary with income level, did not produce significant results for a regression involving the whole sample."*

To summarize, Canning and Fay [8] obtain evidence that transport investment is most productive in industrializing economies and less so in underdeveloped, largely rural economies. They also show that developed economies are experiencing lower marginal products of infrastructure, which is due to the fact, that they already have a high quality transport system in place.

Support for this idea can also be found in Rephann's conclusions [15]:

- *Road investment appears to have a greater effect on economic activity in the less industrialized regions such as the Sunbelt.*
- *Extremely underdeveloped regions are less promising candidates for road development than regions in an intermediate stage of development which are experiencing low growth.*
- *Additional roads may result in diminishing marginal returns.*

Hence, Rephann [15] finds that extremely underdeveloped regions *are less promising candidates* for road development than regions in an intermediate stage of development which are experiencing low growth. This implies that there is some critical stage of development (industrialisation) where transport infrastructure plays a crucial role.

As far as the difference between highly developed and less developed countries is concerned, Button [6] comes to compatible findings. He conducts a meta-analysis of infrastructure investment studies. He finds significant differences of infrastructure investment "returns" between "developed" (i.e. USA) and "developing countries" (other countries). One of the conclusions is the following:

"Interestingly, the dummy variable indicating whether a study was of US origin or not is highly significant and suggestive of the fact that US studies, other things equal, tend to produce lower elasticities than do studies conducted elsewhere. Theoretically this can be explained in terms of the substantial base level and quality of infrastructure found in high income countries and the scale, scope and density economies which accompany this. Additional infrastructure in this context may provide little additional potential stimulus especially if the economy enjoys flexible labour and private capital markets. What it does

imply, however, is that previous surveys which have, in the main, tended to concentrate on the North American literature may, assuming the direction of causation is from infrastructure investment to economic stimulus, have been under-estimating output elasticities in many parts of the world."

In the footnotes (ibid.), a significant point is made:

"Since the United States is a high income country it may be that countries with high GDP per capita do have lower elasticities rather than there being an explicit nationality effect in play."

The elasticities Button is referring to are output elasticities of public infrastructure investments in the respective estimated production functions. It needs to be stressed that Button considers *all* infrastructure of an economy and *not just* transport infrastructure (although transport infrastructure does represent an important part of it). So at best, one can regard the results of this study, which are clearly in line with the findings of Canning and Fay [8], as indicative.

In a very comprehensive book on transport investment and economic growth, Banister and Berechman [4] give a thorough description of the link between additional investment in transport infrastructure and its social returns - they talk about declining marginal "economic development effects" of transport investment:

"…the degree to which infrastructure improvements will affect economic development is obviously not independent of the level and performance of the in-place capital infrastructure. Thus, in areas where the stock of the transport infrastructure is highly developed, even a sizeable infrastructure investment is unlikely to affect travel behaviour and markets significantly and, as a consequence, economic development. In general therefore, we can expect, ceteris paribus, a declining marginal "economic development effect" from additional infrastructure investment. At the extreme, when the region's transport infrastructure is fully developed so that any additional investment will not improve accessibility, no economic gains from the investment (save from the multiplier effect) will result."

To conclude with the evidence, Oosterhaven and Knaap [2003] argue that *"the literature appears to agree that the generative effects of new or improved infrastructure are minimal when mature, well-developed economies are involved. The redistributive effects at lower spatial levels of analysis may be larger, especially when network bottlenecks are removed. The principle reason for this general conclusion lies in the small relative reduction in generalised transport costs that is attainable in mature economies. One may only expect sizeable reductions when entirely new transport infrastructure with structurally lower transport costs or times, is under consideration. But even then, as in the case of the Transrapid rail variants, impacts may be moderate, as the relative reduction over the whole transportation chain is much lower than that over the new rail part of the chain. Moreover, mature economies typically supply competing modes of transportation (road next to rail) which further reduces the impacts of infrastructure improvements, especially when the latter concern the mode with the smaller modal share, as was the case with the Transrapid application.* Conversely*, the impacts of new infrastructure in developing countries - for the opposite reasons - often are considerable. Such countries have fewer or no competing transportation modes, whereas the existing modes are of such a low quality that most improvements tend to result in relatively large relative reductions in generalised transport cost."*

5 INTERPRETATION OF THE EVIDENCE REGARDING THE RELATIVE IMPORTANCE OF TRANSPORT INFRASTRUCTURE INVESTMENTS FOR ECONOMIC GROWTH

The following scatter diagram (figure 2) presents the marginal product of roads in 1985 that was computed by Canning and Fay [8] plotted against data about PPP GDPs per capita for the single countries in the same year. We opted to use the computed marginal product of roads and not the rates of return because of already mentioned difficulties with data on prices of roads.

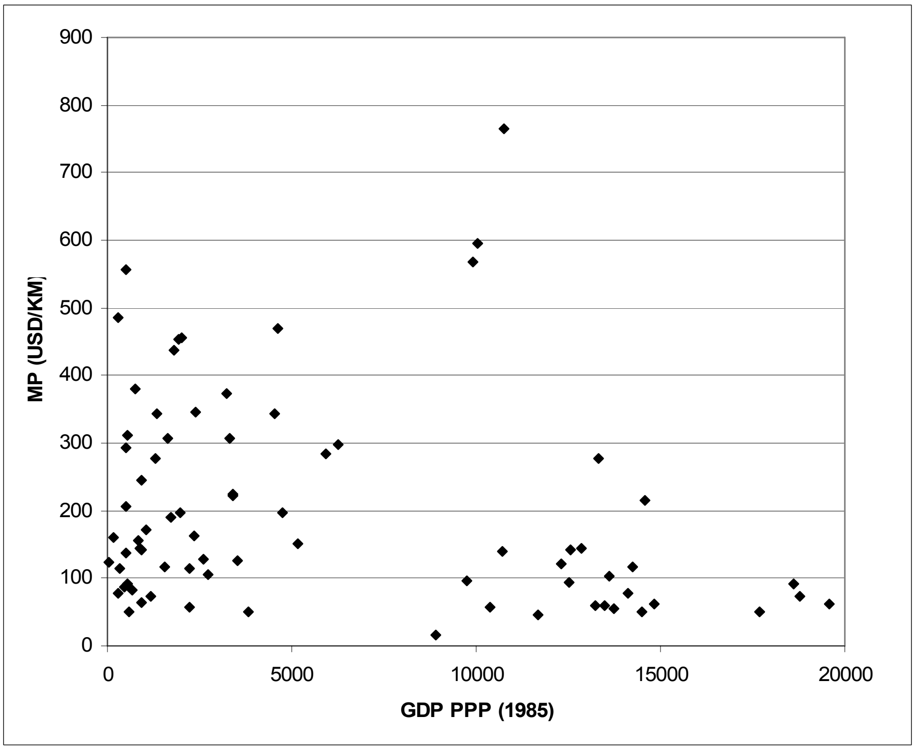

Figure 2: Scatter diagram – Marginal product of roads against GDP PPP per capita [8] [17]

One may see that there are two clusters in the diagram. One is the cluster that represents developing countries and the second one is the cluster that represents developed countries. It is evident, that highly developed economies have a lower marginal product of roads and the values for these countries seem more homogenous. Conversely the marginal products of roads for developing countries seem more scattered and generally higher. This leads us to suspect that the data suffers from heteroscedasticity. Keeping this in mind, we fitted the data with a third order polynomial curve. Although statistically disputable, this curve wraps up the key findings of the previously quoted studies and presents a stylized fact that is utterly plausible.

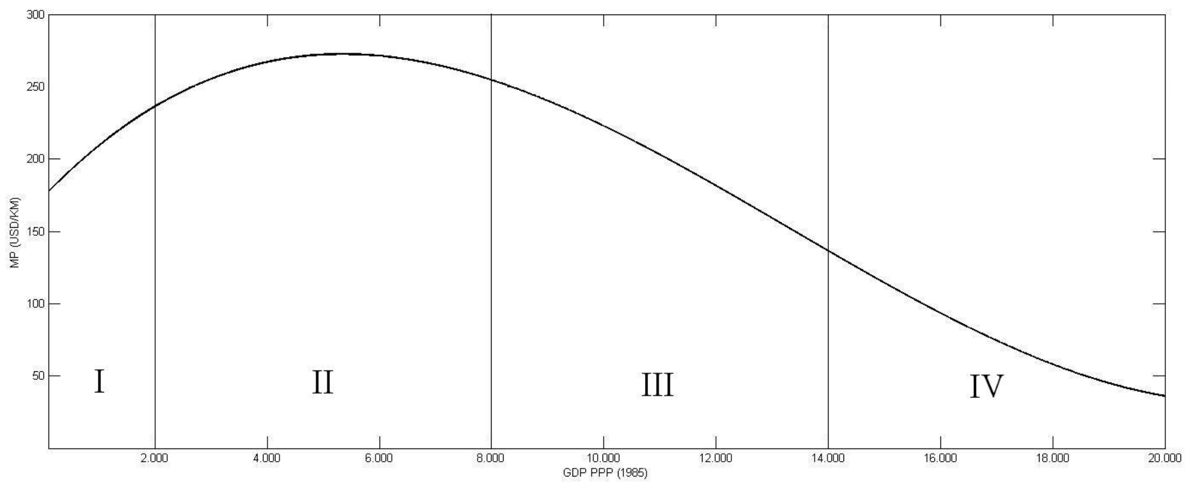

Figure 3: Interdependence between marginal product of roads and GDP PPP per capita [8] [17]

Figure 3 depicts the stylized relationship between the marginal product of roads and GDP per capita. It reflects the finding of the quoted authors that countries in the process of industrialisation (II) exhibit the largest marginal products of transport infrastructure, which implies that these countries should be investing in the expansion of their transportation network. On the other hand, poorly developed, predominantly rural economies (I), exhibit a significantly lower marginal products, which means that other types of investments might be more important than transportation infrastructure. As far as the most advanced economies are concerned (III and IV), they obviously have large transportation networks in place and exhibit diminishing marginal products of transport infrastructure.

6 CONCLUSION

Based on a literature review regarding the macroeconomic effects of transport infrastructure investments on economic growth it may be concluded that the macroeconomic effects of transport infrastructure investment significantly depend upon the level of infrastructure endowment relative to the gross domestic product of a country.

Countries in the process of industrialisation exhibit the largest marginal products of transportation investment, which implies that these countries should be investing in the expansion of their transportation network. On the other hand, poorly developed, predominantly rural economies, exhibit a significantly lower marginal products, which means that other types of investments might be more important than transportation infrastructure. There is no use of additional transport infrastructure investments, if the regional or national level of development did not yet reach a level that would require extensive transport infrastructure investments.

As far as the most advanced economies are concerned, they have abundant transport infrastructure in place and exhibit diminishing marginal products of transport infrastructure. Therefore investment in additional units of transport infrastructure is of marginal importance and brings also relatively small results.

We believe that the presented “hypothesis” of interdependence between transport infrastructure development and economic growth will be of help to future interpretations of sometimes at first glance controversial results of the studies concerned with the impact of transport investment on economic development.

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ABOUT SPATIAL IMPACTS OF TRANSPORT INFRASTRUCTURE

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ABSTRACT

This paper deals with the possible spatial impacts of transport infrastructure from a general point of view. It tries to pose critical questions about the benefits of transport infrastructure by linking conclusions of trade theories to transport infrastructure. By drawing analogies between trade and transport within the New Economic Geography the paper leads to the main question: “Can transport infrastructure increase the total benefit of a region or does it only lead to shifts between the sub-regions?”

1 INTRODUCTION

This paper will pose several questions regarding the spatial impacts and effects of transport infrastructure. Various theoretical approach will be interlinked and a combination of some conclusions will be delivered. There will be shown up possible connections between theories of trade on the one side and transport infrastructure on the other side.

What kind of effects does transport infrastructure have on regions? Which opportunities or challenges do transport linkages pose on regions? Here the opinion of the scientist vary without leading to consensus [11] and further more basic questions arise. First, the geographical level of the analysis has to be decided, i.e. if we look on a small region, a country, a continent or the whole world. Then, of course, the question about “effects” has to be made. Do effects include economic, social, ecological and welfare effects? Or even more? In this part the inclusion of external effects is crucial and it is clear that effects are somehow a combination of costs and benefits in a broad sense.

2 NETWORKS AND ACCESSIBILITY

Coming from the side of cybernetics, the study of the structure of regulatory systems and systems theory [15], which explains the behaviour of complex systems, some remarks on networks are presented to start with. Fig. 1 shows three steps of a development of a network.

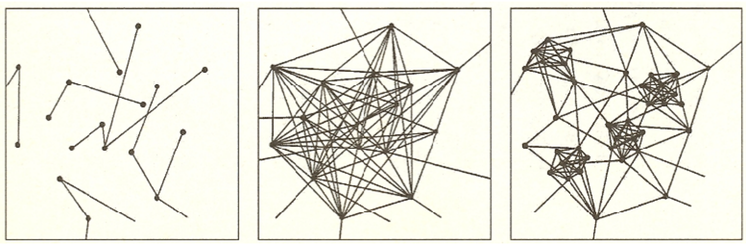

Figure 1: Complex systems and networks [15]

Firstly, a network improves stability. Continuing the addition of connections the network gets too dense and the stability of the system will be reduced due to self-blockades. Thus, a system needs some kind of sub-structures instead of a homogeneous dense network in order to remain or improve its stability [15]. Are these general conclusions transferable to transport systems and its connections? Congestion is probably one kind of self-blockade resulted by too dense road networks.

Another example where a higher density of transport infrastructure and higher accessibility leads to loss of attractiveness is shown in Fig. 2.

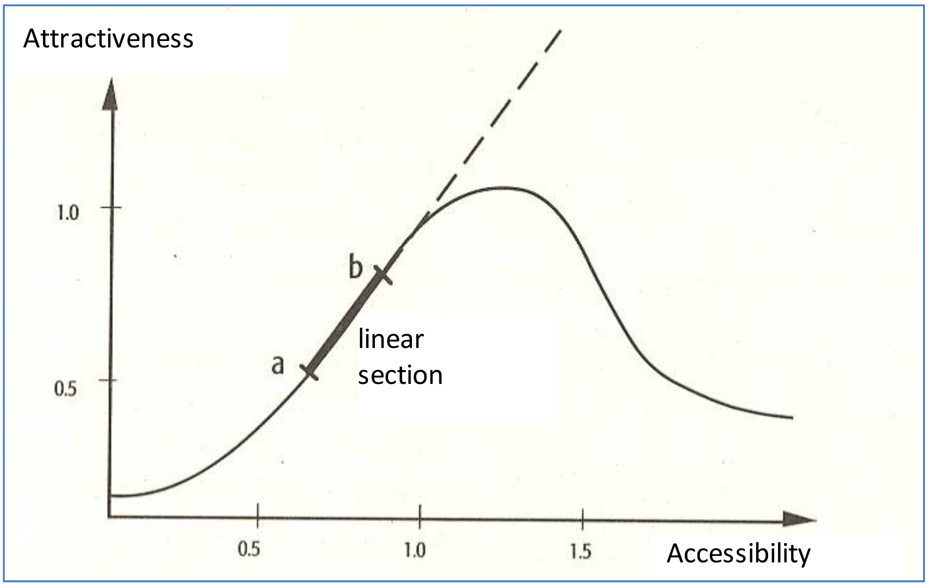

Figure 2: Attractiveness of landscapes and accessibility [15]

The Figure shows that first (for humans) the attractiveness of a landscape rises with higher accessibility as the visitors can more easily reach the area. But having passed a point of maximum the attractiveness diminishes due to high accessibility, which can be effects of realized (traffic, noise) and potential accessibility (ugly motorways, destroyed landscape).

3 ACCESSIBILITY AND REGIONAL EFFECTS

The next main question of the paper is, if there is a state of transport infrastructure which generates a maximum of benefit in a region or a country. This means, can we rise the benefit always further − even though very little − by extending the transport infrastructure? Or is there a point of maximum where further infrastructure leads to loss effects? It is probably the latter version, but how can we determine this status of maximum?

Apart from defining the limits of a region, we need to analyse the relation between the various modes of transport and its infrastructure. Equally difficult is the definition of costs and benefits as there are numerous causal and interdependent relations regarding the impact of transport infrastructure which are not easy to extract [11].

Related to Fig. 1 it can be raised a further question: “Does an improvement of the transport infrastructure lead to higher accessibility?”. And even more important: “Does an improvement of accessibility lead to general economic effects? Or does it only lead to economic shifts between the regions?”. Put it in another way, it is to be analysed if infrastructure can increase the total benefit of a region or can only sub-regions grow on the cost of other sub-regions? Here, many scientist assume that only re-distribution is the case instead of new growth [16]. Next chapter will show that the opinion of various authors lower transport costs primarily would strengthen the agglomerations, i.e. the core areas [7] [2].

Continuing these thoughts even further, it should be analysed, if a constellation is possible, in which an improvement of transport infrastructure could lead to a loss of total (gross) benefit. For example, that the benefit in the agglomerative sub-region A growth less, than the benefit in the peripheral sub-region B does diminish, i.e. the gain in A are smaller than the losses in B.

The reasons behind this could be that accessibility improvements could lead to loss effect in the periphery [10] [9]. These could be the loss of regional monopoles in peripheral areas by new transport connections. Central producers can extend their customer radii on the periphery and the local commerce is not any for rentable. Also possible are industrial relocation from the periphery to the core, as due to better transport connections the working force can commute larger distances and the companies do not need to establish a plant in the periphery to employ the peripheral working force. All in all, these loss effect in the periphery could be stronger than the improvements in the core region. These concentration effects of services (customers), industry (worker), etc, are illustrated in Fig. 3.

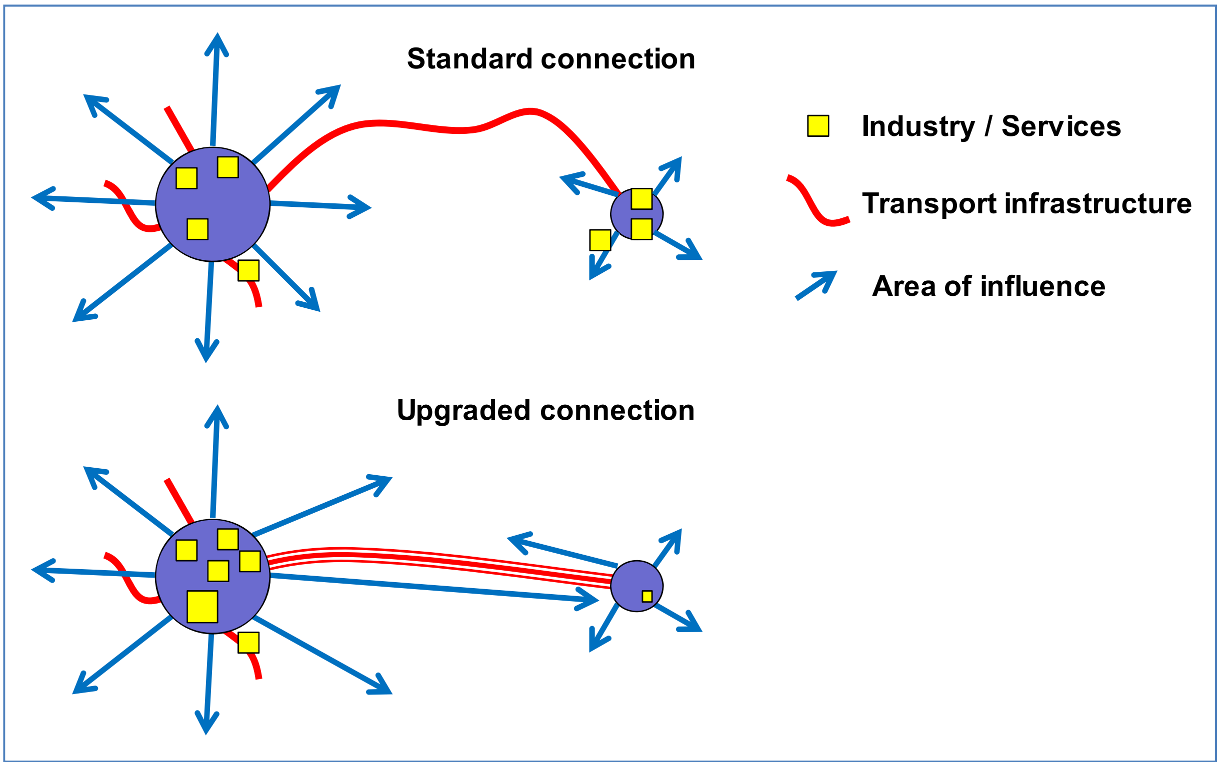

Figure 3: Concentration effects by upgraded connections.

This shows that by the upgraded connection between the core (left) and the periphery (right) the area of influence is raising for both the core and the periphery, but first the influence of the core is reaching the periphery and thus gaining parts of its industry and services as described above. It can also be said that the costs of supplying the periphery are lower.

Transport infrastructure is necessary, but not sufficient for economic growth. Especially for regions with high-quality infrastructure "soft" location factors are more and more important, because new transport infrastructure barely leads to an exploitation of new markets, but only to reduced travel times on few unimportant relations. In the western parts of Germany already since the 1970s it is not possible to detect a direct correlation between motorway accessibility and economic development [4]. It demanded to find alternatives for "old-fashioned" calculations on macroeconomic cost reductions through accessibility improvements [11].

4 TRANSPORT AND THE NEW ECONOMIC GEOGRAPHY

There are various theories about the effects of trade, trade barriers and free trade on the development of countries and regions coming to various results. Many of these theories examine the effects of trade costs and also of transport costs, but these two costs are used inconsistently. Sometimes transport costs are part of trade costs, while in other cases transport costs embrace trade costs and yet in other theories both cost aspects are equivalent and do correspond each other.

Thus, the question arises if there are parallelisms and analogies between trade costs and transport costs and similarly between trade barriers and transport barriers. If the answer is yes, what kind of analogies do we have. It should be analysed if findings and conclusions regarding effects from trade barriers and trade liberalisation are transferable to effects from transport infrastructure shortcomings and improvements.

The New Economic Geography (NEG) was mainly developed and popularised by Paul Krugman the Nobel Prize laureate of 2008 and Masahisa Fujita and Anthony Venables. Spatial viewpoints were heavily underrepresented in mainstream economy. The NEG for the first time succeeded to include spatial distributions in an economic theory and into formal calculation models. It delivered the theoretical ground for simulation models of spatial equilibriums in economic science [8] [3]. The NEG is a modelling of the self-organisation of space, but in most cases an analysis of specific, historic and casual developments are also necessary to correctly simulate the spatial developments [5].

Without entering in details it can be said that the models of the New Economic Geography simulates the interactions of centripetal and centrifugal forces. Centripetal forces are leading to concentration and thus are supporting the core areas, while centrifugal forces are acting towards the periphery (see Fig. 4).

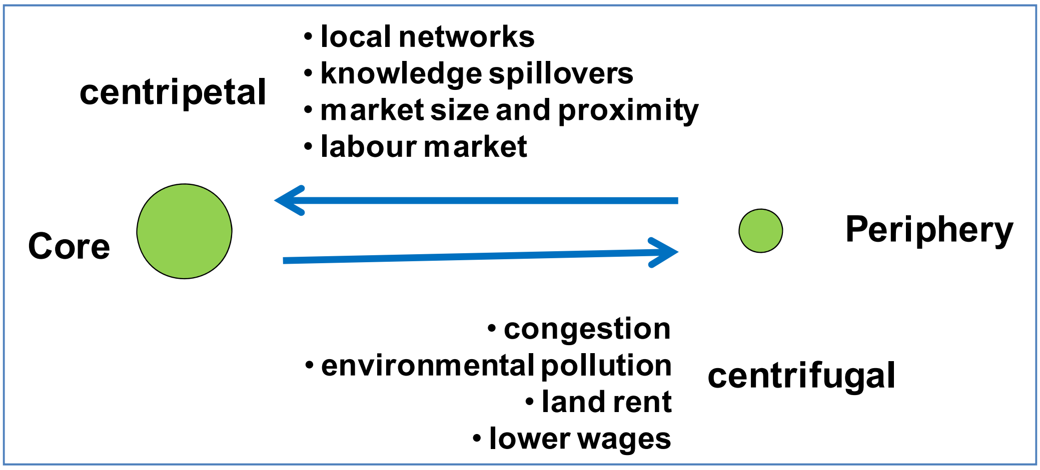

Figure 4: Centripetal and centrifugal forces

As a central point of the theory, the NEG predicts that as a first step sinking trade costs in a broad meaning leads to trade and wealth in both regions. Then, further sinking trade costs leads to a critical point, where a core and a periphery is created, where the latter loses wealth due to above mentioned reasons. Later in a variant B, even lower trade costs can lead to a renewed equalisation of the level of wealth. This can be illustrated again in Fig. 3 as with even better transport connections the area of influence (blue arrows) of the periphery reaches the core area, too. So not only the core's influence is extended to the periphery but also vice versa.

Next Fig. 5 demonstrated the relation between trade costs (transport costs) and the spatial distribution of the economy between core and periphery.

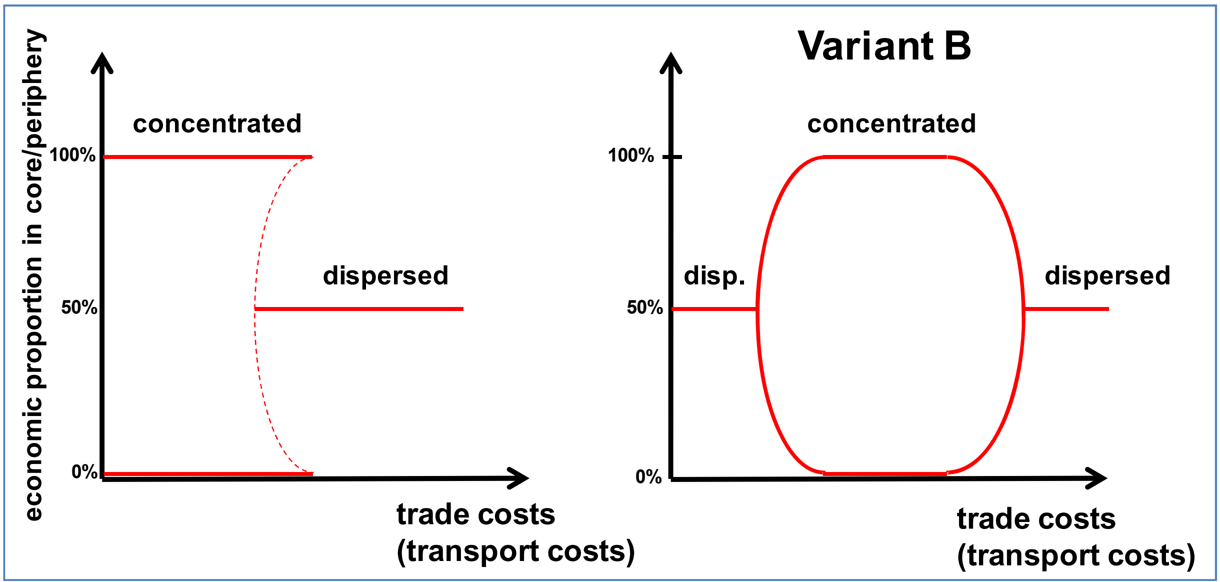

Figure 5: NEG. Trade costs and spatial distribution [13]

Left part shows the classical version of the NEG. Coming from the right end of the red line, i.e. high trade costs, the economy (or a specific sector of the economy) is dispersed and equally distributed between the two observed regions (both 50 %). Then the trade costs are sinking and the line reaches a critical point where it is split up and a concentrated situation emerges with 100 % of the economy in one region. Lowering the trade costs even more does not changes the situation after this first version of the NEG. Special attention should be drawn on the curved dotted line between the concentrated and dispersed situation. When the critical point is passed from dispersed to concentrated by lowering trade costs and then the trade costs are raised again, the spatial distribution does not switch back to the dispersed situation at the same level of trade costs but continues in the concentrated state. Only raising trade cost further will lead back to the dispersed situation. This effect is called the hysteresis effect [13].

On the right sight is shown variant B, where very low trade costs are leading again to a dispersed spatial distribution and the hysteresis effect is missing [13]. A combination of the classical version and variant B is also possible.

Now it has to be asked if these models about trade costs in a broad sense are transferable to transport costs in a narrow view. The theory shows that under certain circumstances free trade can lead to spatial specialisation and does not result in growth of wealth for all involved regions or countries and initially only supports the stronger partner. Rich countries support free trade in the sectors where they their strength in order to save their supremacy and to hinder the rise of developing countries in these industrial segments, while they had high tariffs during their own growth phase and are still protecting several sectors. This could be named “Kicking away the ladder” [1].

A consequence of this would be that weaker regions first should try to develop in a sector and only after having reached certain level the economy should be connected. Then again the development should be forces before connected even more, etc. Concluding from this, for each region there should be an optimal level of trade liberalisation, which corresponds to the specific level of development of the region.

And if these mechanisms regarding trade costs are analogue to those of transport costs, this should also apply to an optimal level of transport infrastructure connections of a region to the outside. For weaker region this could mean that development strategies could be necessary which limit transport infrastructure connections until the local companies can also profit from raising economies of scale and can stand the competition of the core areas [12]. So it can be possible that it is not optimal for all regions to demand a high level infrastructure connection to the rest of the continent before having reached a correspondent level of economic development.

5 CONCLUSION

Whether economic or transport integration leads to cohesion or disparity depends on many parameters which include the type of market competition, the form and amount of regional specialisations, the interregional mobility of workers, etc. [6]. These parameters are defining how easy the core can extend its area of influence shown in Fig. 3 for example. If the workers are not willing to commute from the periphery the industry is forced to stay in the periphery.

Of course, transport infrastructure is not always negative for weaker regions, but in some cases less infrastructure could mean more benefit for the region. The parameters of the analysed regions decide if transport costs assist an equilibrium or an imbalance of economic activities [14]. Thus, based on the NEG already since 2000 economic and development policy suggestion were extracted.

The latest developments are combining the so called evolutionary economics with the NEG creating models where small changes of the initial parameters are leading to completely different spatial structures and these resulting differences are hard to overcome [14]. Here parallels to the chaos theory and non-linear systems are revealed and maybe it is shown once again that most parts of socioeconomic development is not predictable and does not fit in calculation models easily.

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