Comparable cost calculation for infrastructure of road and rail

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Abstract

The German Ministry of Traffic and Construction assigned a consortium including the Institute for Economic Policy Research (IWW) to create a cost calculation study, which covers all federal freeways and highways, in April 2001. The main goal of this study was to show the detailed costs for individual user groups and deduce road prices for large lorries. The approach is based on a full cost coverage scenario of the whole road infrastructure, incl. renewals and maintenance. Marginal costs and external effects are not part of this study.

In order to achieve a fair cost comparison between road and rail the DB AG and the IWW decided to transfer methods of road cost calculation to rail infrastructure. For a better comparability to highways / motorways the partners chose seven routes with middle to high train frequency. Parts of the tracks belong to the Trans European Network (TEN).

The most important input data and assumptions for a cost scenario are: kind and number of infrastructure parts, costs and age of infrastructure, description of trains, amount of trains, weight of trains, costs for renewal, maintenance, interest rates and rate of inflation.

The complete proceeding of the IWW model is described in the following chapters.

The main results of the cost analysis are:

- Cost of capital (depreciation and imputed interest) represents the biggest fraction of costs.
- Costs of wear are relatively low, only less than a quarter of capital cost is linked to usage of infrastructure.
- Costs for additional trains are very reasonable if infrastructure needs no changes.
- Rail infrastructure is highly competitive to road in several markets.

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1 Introduction

The German Ministry of Traffic and Construction assigned a consortium of the Prognos AG and the Institute for Economic Policy Research (IWW) in April 2001 to create a cost calculation study (IWW / Prognos, 2002). The work covered all federal freeways and highways. The main goal of this study was to show the detailed costs for individual user groups and deduce road prices for large lorries. The approach is based on a full cost coverage scenario of the whole road infrastructure, including renewals and maintenance. Marginal costs and external effects are not represented in the study.

In order to achieve a fair cost comparison between road and rail the DB AG and the IWW decided to transfer road cost calculation methods also for rail. Situation for both modes of transport was partly the same: It was not possible to deduce the costs to different user groups.

Especially for rail the results of cost calculation studies for infrastructure looked very bad. Trains contributed a significant lower level of their costs, so it seemed to the experts that investing in road infrastructure must have a much greater benefit to the public.

This is not always true! This paper with the main focus on rail will show that transportation on rail is not always more expensive to the public than transportation on road. The studies carried out by the IWW do not include cost coverage indicators, but it can be demonstrated, transports on rail are as expensive as transport on road. Main requirement for this fact is a comparable framework.

2 History

When Hotelling in 1938 wrote his groundbreaking essay on cost calculation and segmentation of infrastructure, nobody was really aware of the consequences in later decades. The following years showed no important discussion and results in this sector of research in Europe.

In continental Europe the European Community (EC) gave a initial spark on this topic. The EC published a study with the main focus on a model for raising user charges (Aberle, 1969, p.32). This survey was made by the scientists Allais[2], del Viscovo, la Vinelle, Oort and Seidenfus in 1965

A first attempt in Germany to calculate costs and to compare the different modes of transport was made in 1969 (Bundesministerium für Verkehr, 1969). The work showed details on road, rail and waterways. One main thesis mentioned in the study was that political reasons are often responsible for a low coverage of costs. Especially the different legal and financial framework causes unfair market conditions (Bundesministerium für Verkehr, 1969, p. 18). This report was a milestone in

[2] The study is widely known under the name of the scientist Allais (Rapport Allais).

German cost calculation for infrastructure. It caused a long series of discussion in different journals and other publications.

Mackenroth (Mackenroth, 1969, p. 217) mentioned the incomparability of cost calculation for road and rail. Investments in rail infrastructure have a strong aim to get a good rate of return, investments in roads are made by political decisions. Seidenfus pointed out (Seidenfus, 1969, p. 211) that a calculation for external effects was missing.

In 1972 Rothengatter proposed a model, which will create an optimal scenario, if the social costs of traffic are optimised. Furthermore the model was one of the first to handle cost calculations for urban traffic.

Four years later the European Community issued a study which showed detailed cost scenarios of traffic for the economy (Kommission der Europäischen Gemeinschaften, 1976).

Concerning external effects several studies were carried out in the last decade. In 1994 IWW and INFRAS published a major work assigned by the UIC (IWW / INFRAS, 1994).

In Germany the DIW has the most experience in cost calculating for infrastructure. In order to the Federal Ministry of Transport and other institutions the DIW created studies with this topic in 1972, 1975, 1978, 1981, 1984, 1987, 1991, 1994 and 2000 (Link, et al., 2000, p. 1).

In the past years infrastructure databases were enhanced and abilities of computers grew enormously. This is the necessary background for inventing a new cost calculating scheme by the IWW.

3 Method

The IWW studies as well as in this paper focus on calculating the full costs of infrastructure for traffic. Second emphasis is the process of a fair allocation of costs. There is no coverage of external effects.

To get the complete costs of an infrastructure for traffic the IWW put three kinds of costs together:

- Costs of capital (depreciation and interest on fixed capital).
- Costs for running (operation and service) the infrastructure.
- Costs for maintenance of the infrastructure.

The full costs can be calculated by adding up the three groups of costs. The aim is to get the most realistic data for a certain point of time. To achieve this goal a database was created. The database contains several figures, e.g.:

- Existing parts.
- Costs of construction.
- Age and expectancy of life.

- Likelihood of breakdown.
- Forecast of load.

3.1 Compilation of costs

The IWW infrastructure model examines the complete rail infrastructure, excluding stations. Following parts of rail infrastructure are covered by the model:

- Superstructure (rails, switches, sleepers, ballast)
- Substructure (earth-works)
- Special Buildings (bridges, tunnel)
- Signalling (signal, signal box, etc.)
- Electrification (power lines, substations, etc.)
- Telecommunication
- Railroad crossing
- Noise protection (walls)
- Ground

Prices for components are referred to one certain year. In latest studies of the IWW the year 2000 is taken as the gross value basis. The value for the year 2000 is not an addition of all values of erecting. For further calculations net values of infrastructure are needed. The net value of each part of the infrastructure is the result of a multiplication of the gross value with a so called "indicator of state". There is an "indicator of state" covering every part of infrastructure. It is defined as division estimated remaining lifetime through total estimated lifespan.

For estimating the forecast lifetime of an element of infrastructure information on age, state (quality) and changing traffic is used in the model.

The advantage of an "indicator of state" in comparison to an indicator of time is the possibility to get an exact value at the examined point of time. If there is the knowledge of the state and value of every relevant part, then fixed capital can be evaluated and depreciation can be calculated on the base of a forecast on remaining lifetime and a traffic forecast. On fixed capital interest is paid. IWW used a interest rate of 3 %.

An addition of depreciations and interest on fixed capital is carried out to get the cost of capital.

Second part of infrastructure costs are expenses for operation and service. Following items are responsible for main fraction of costs:

- control of trains (e.g. switches)
- security of trains (e.g. signals)

- management of trains (e.g. timetables)

Third column in this context are costs for maintenance of the infrastructure. Costs can be divided in

- regular recurrent measures (e.g. grinding of rail)
- erratic recurrent measures (e.g. to keep the track clear of snow)

In order to get the complete costs of infrastructure, all cost elements (costs of capital, operation and maintenance) have to be added up.

3.2 Separation of costs

The following components are part of the IWW model, which are used in the infrastructure cost allocation studies for road and rail. Costs are divided in three different parts to get a fair fragmentation:

- Cause and origination of measures,
- consumption and deterioration of infrastructure and
- overhead costs.

First, the IWW model tries to find out, who is responsible for construction of a separate parts of infrastructure (e.g. special signalling for high speed trains) or which kind of traffic needs an infrastructure with specific parameters (low gradients for freight trains). In Germany most tracks are used by passenger trains as well as by freight trains. Due to this fact a separation of costs is not easy to carry out. An exception is the new high speed line between Frankfurt and Cologne. This line is only used by high speed passenger trains.

The second column of the cost separation is the division of costs caused by wear. The wear of infrastructure has two main causes:

- Trains using the infrastructure and
- the infrastructure itself (quality, location,…).

As an example the wear of rail will be explained in detail. The following figure shows the dependence between trains and rails.

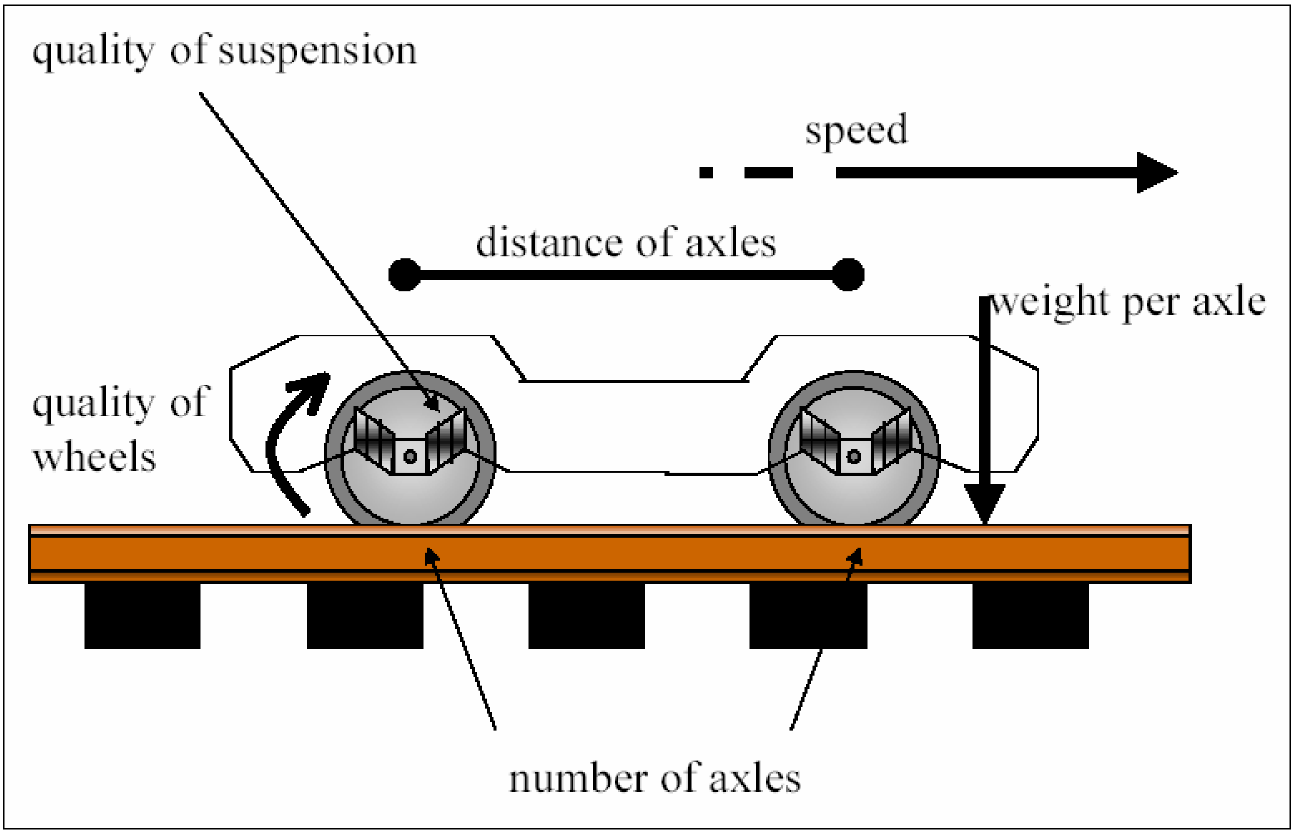

Fig. 1: Wear of rail caused by trains.

In comparison to road, most part of the tracks are straight and gradients are relatively low. Under these conditions the wear is caused mainly by the weight of axles and the speed of the train. Especially the parameter of speed is often underestimated. In the last decade some research took place at the University of Hannover (Schroeder-Baumgart, 1993). Related results were made some years before at several institutions. The following graphs show the wear of different types of rail. When the measurements took place only ballast based superstructure was available. In our days results for high speed trains should be significantly better based on a higher quality of the superstructure.

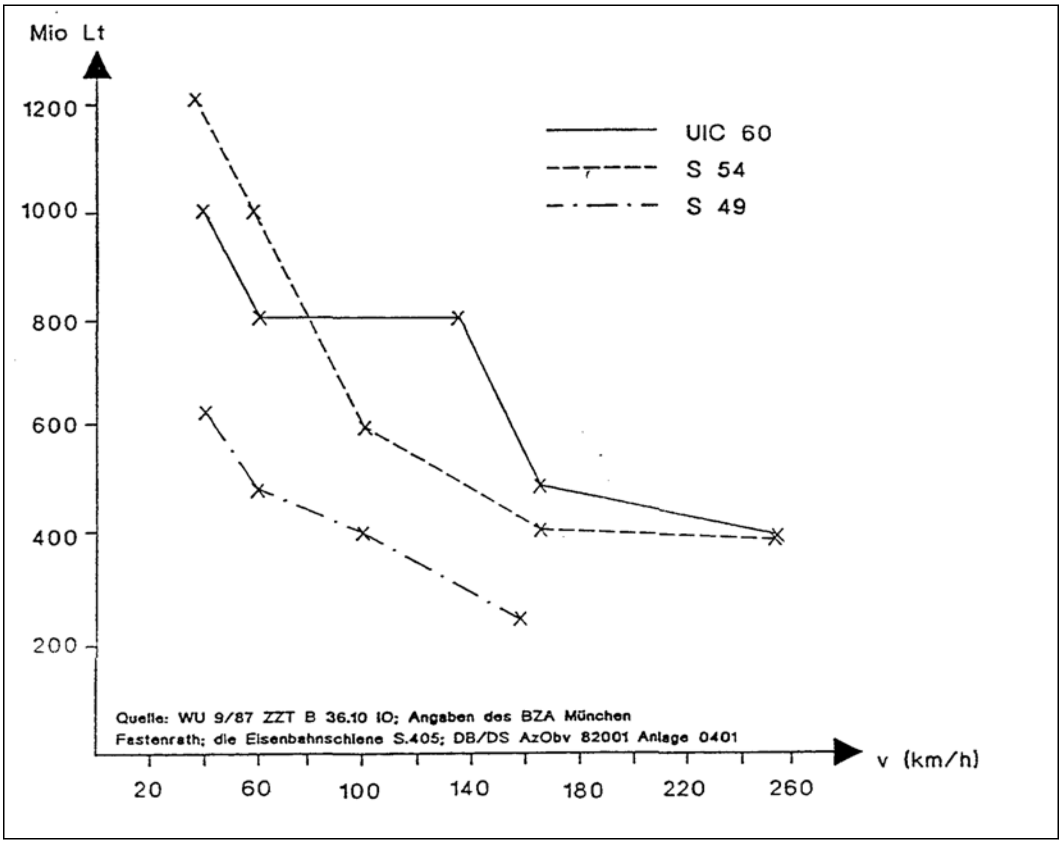

Fig. 2: Decreasing capability (in Tonnes) of rail in dependency to speed (Schroeder-Baumgart, 1993, p. 18)

There are different reasons resulting from the state of the infrastructure, which are the origin of boosted wear. The wear is caused by trains running on the infrastructure, but it would not take place if infrastructure had ideal parameters. Following reason can cause intensified wear:

- Radius of track
- gradient of track,
- quality of infrastructure and
- quality of maintenance.

At the moment the IWW database is not sufficient to cover all these complex parameters. To get the model started, following train classification is used:

- Type (passenger, freight),
- Speed (from 80 km/h to 300 km/h) and
- Weight (from 50 t to 5000 t).

The third column represents, the costs, which every train has to bear. Due to the fact that most parts of infrastructure are necessary for and used by every train these costs are the biggest part of the calculation. E.g. a bridge is used by passenger and freight trains. Both types of train need this bridge, the only difference is that freight trains need a more stable construction. The price of a more stable construction is eventual 10 % higher a pure passenger train construction. This example is representative for most parts of traffic infrastructure, so every user (train) has to bear same costs in this segment. And as a matter of fact a long and heavy train needs the same capacity like a small railcar. This is due to the fact that in one segment of a line only one train is allowed. At the moment these segments are widely fixed (points of signals), changes will take place in the next couple of years.

3.3 The Model

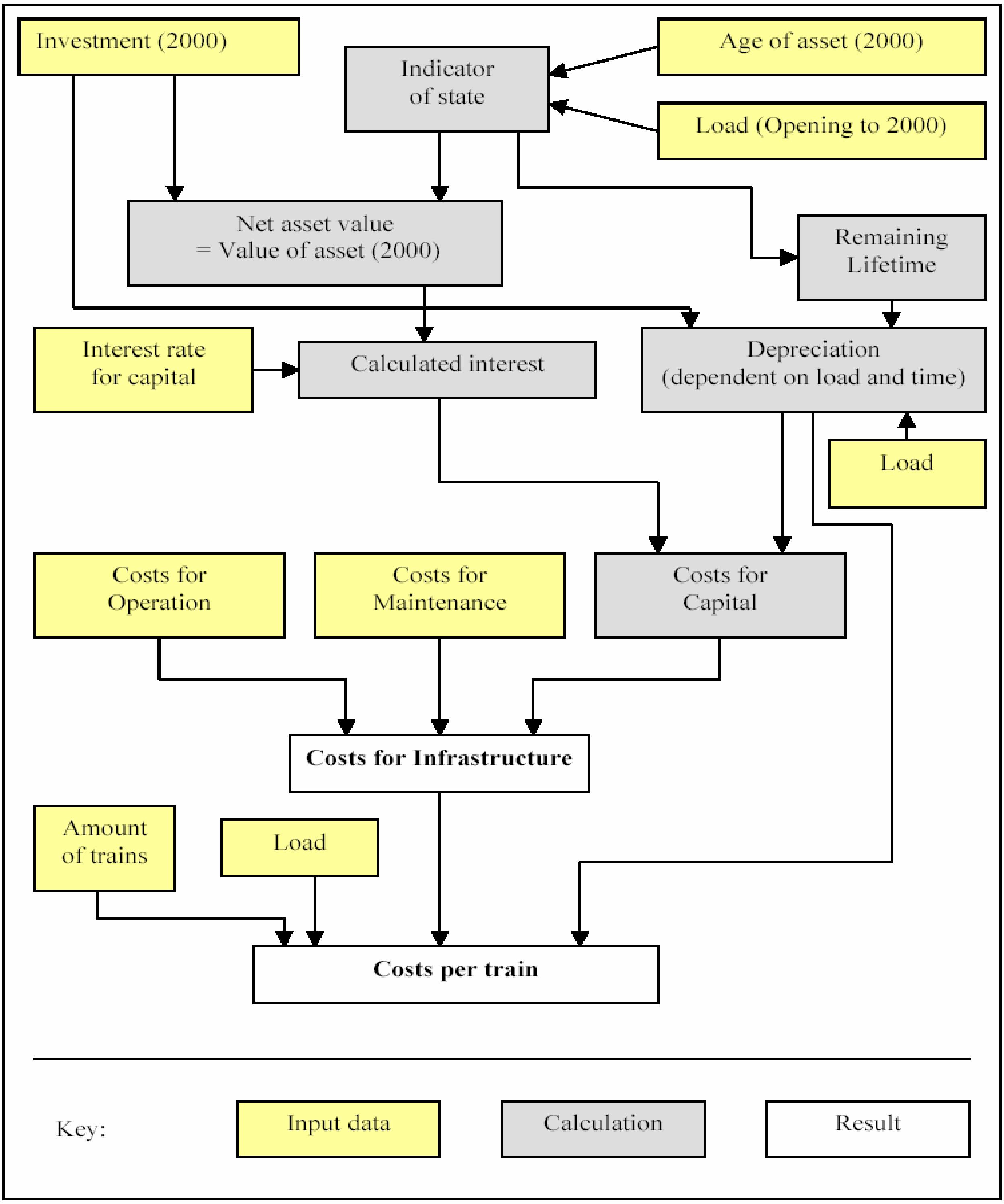

Fig. 4: The schematic model of the IWW infrastructure cost calculations.

4 Results

In comparison to many other cost calculations on rail infrastructure the IWW work is concentrated on a relatively small part of the network. The work covers tracks with a length of approximate 2500 km divided into seven trans-German and regional routes. No part of the analysed network had a low train frequency. A high utilization of tracks was necessary to create a fair comparison to appropriate motorways.

In relation to other cost calculation studies this work assumes a significant higher value of assets. This is caused by assortment of lines. In comparison to figures of the DIW (Link, et al., 2002) the lifetime reduced by around 10 %. The most significant differences could be found in the number of trains. In the shortened IWW network, six times more trains run than in the average network.

The capital costs are responsible for three quarters of total costs. Costs for operation and maintenance are astonishing low in comparison to capital costs. Load has no relevant impact on the costs.

Comparisons between road and rail have a long tradition in the field of infrastructure cost calculations. The results for rail often were not encouraging (Link, 2000). In this survey rail looks much better. Especially costs for freight transport are competitive (Fig. 5). Results for passenger transport show similar results for road and rail.

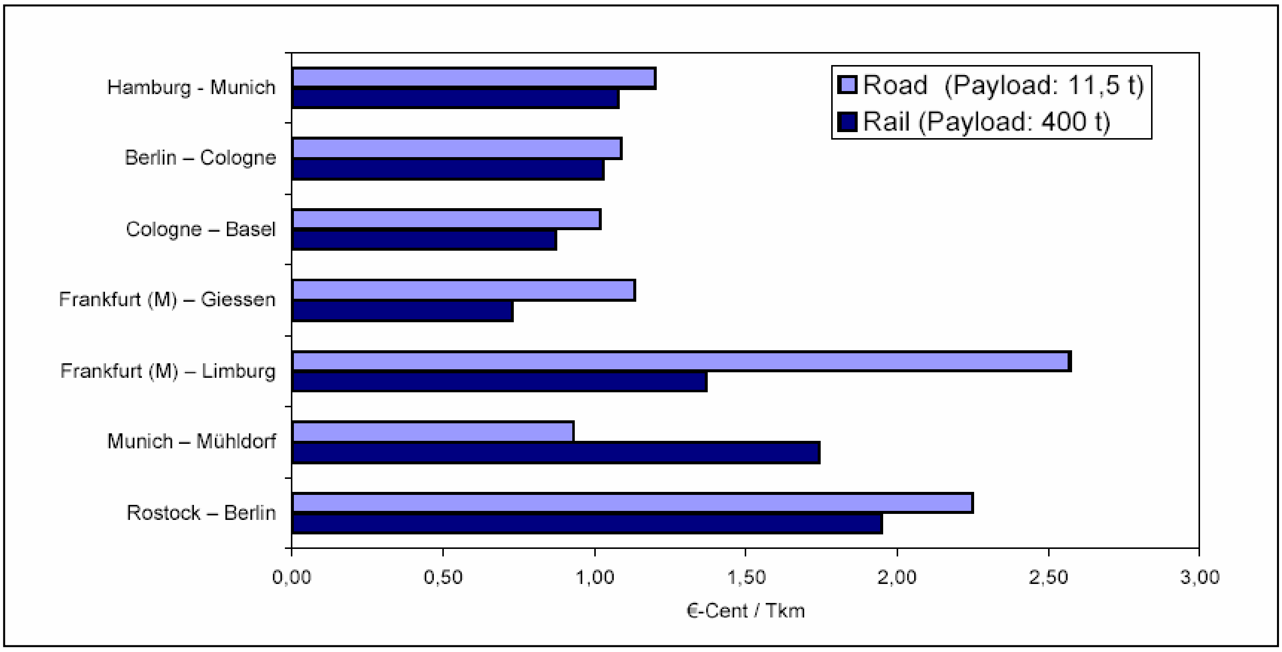

Fig. 5: Comparison between road and rail in freight transport on different routes.

Assumptions for payload were 400 tonnes at rail and 11,5 tonnes at road. Figure 5 shows the difference between high density routes (Hamburg – Munich, Frankfurt – Giessen) and a lower density route (Berlin – Rostock). The reason for low costs on the route Frankfurt – Giessen is a simple (e.g. no tunnel), already depreciated and well used infrastructure. Expensive assets on the route Hamburg – Munich (High Speed Line between Hannover and Würzburg) cause big amounts of interest and depreciation.

5 Conclusions

The first conclusion is the fact that railway lines with a high density of traffic are the cheapest. The more trains you run the cheaper is the single one. It does no matter who is causing the high density: passenger trains lower costs for freight trains and vice versa, because costs can be divided through a higher amount of trains. If there are vacant capacities, doubling the amount of trains running on the track will result more than 40 % lower costs for each train on most lines. Decision maker should think about extending the payload of trains, because load has a relatively small influence on costs.

Capital costs are the main segment of costs. Especially the older high speed lines (Hannover – Würzburg, Mannheim – Stuttgart) in Germany are causing extremely high capital costs. Upgrading an existing infrastructure is much more cheaper than erecting a new line or track.

Comparisons between road and rail should be fair. Existing infrastructure cost studies have compared the costs for the whole railway infrastructure (main lines and branch lines) with costs for the federal highway system. This has been justified by the argument that both are owned by the same institution. To compare a branch line to road, there should be an adequate counterpart.

In comparison to road railways are highly competitive in corridors with a high density of traffic. There level of costs is not very different to road. On several lines railway can handle tasks of transport much cheaper than road.

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