MARKET ANALYSIS FOR SHIFTING GOODS FROM ROAD TO RAIL BY MEANS OF COMBINED TRANSPORT IN GERMANY

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ABSTRACT

The current discussion about the necessity of worldwide CO_2 reduction awakens interest of a growing number of companies to check the train as alternative to the truck transport. Additionally a broad public interest and programmes of the governments support the shift from road to rail. There are a lot of general discussions about the need and the advantages of the train transport. But it isn´t said, how much shiftable potential there exist.
One point is, that most of the companies do not have an own railway access and have to use special terminals. This transport of containerised goods to the special terminals by truck and then by train to another terminal is called combined transport (CT).
Another point is that some goods and production concepts have economical and technical requirements, the combined transport cannot fulfil.
Thus, this paper first analyses and identifies which kinds of goods can be shifted from a technical point of view and which kinds of transports are realistic and attractive to shift from an economical point of view. The goods are categorised in primary, secondary and tertiary potential to shift.
Secondly, this paper elaborates on this basis, how much maximum potential that means for the market, and illustrates it in the case of Germany.
The analysis concludes, that in the case of Germany the maximum shifting potential results in 10% of the current truck transports. This means five times more traffic on combined transport than at present.

1. INTRODUCTION

1.1. Concept of the paper

"Transport emissions are still increasing and one third of these are estimated to be caused by freight transport. This trend needs to be stopped if the EU is to meet its greenhouse gas emission targets." (European Commission, 2007)

The European Commission wants to reduce the emission in Europe, with one focus on the transport sector. One way to reduce the emissions is to intensify the use of rail based transport for truck loads instead of road. For example, the study of UIRR (2003) showed on the analyzed relations that up to 60% CO_2 can be reduced due to the use of rail instead of road. The study concludes:

"The shift of traffic from road to rail is an important instrument to reduce the emissions of the greenhouse gas CO2."

Therefore, one clear intention in Europe is to increase the use of rail transports with European and national actions. For instance, the declared target of the national government in Germany (BMVBS, 2008) is to shift noticeably more goods from road to rail and to increase the market share of rail-based transports sustainably.

The German government says that there is still much unused shiftable potential for the rail in general (BMVBW, 2000).

But it isn´t said, how much shiftable potential there exist.

To bridge the gap, this paper analyses the market potential for shifting goods from road to rail and its maximum limit.

Thus, this paper will first analyse and identify which kinds of goods can be shifted from a technical point of view and which kinds of transports are realistic and attractive to shift from an economical point of view. Secondly, this paper will elaborate on this basis, how much potential that means for the market, and illustrate it in the case of Germany.

1.2. Deescription of direct rail freight

The direct rail freight moves goods directly from one production plant or storage space to another on the railway tracks. One train is able to handle large amounts of goods in one drive, which is sometimes very attractive from an economical point of view to transport a large amount in one train than in several trucks.

Additionally, rail based transports are far more attractive from an ecological point of view than road transports. According to UIRR (2003) the railway needs less energy to be moved than an equivalent amount of trucks and therefore reduces the CO_2 emissions. A further reduction of CO_2 is due to the use of regenerative and non-fossil energy resources during the electricity production.

But one disadvantage of direct rail transport is that it requires an access of each company producing goods to carry to the rail infrastructure, named works siding.
Consequently, comprehensive use of this transport mode is not possible for each firm.
Bruckmann (2006) analyses the percentages of firms which have works sidings. He refers to the industrial properties in the Ruhr Area in Germany, one of the largest industrial areas in Europe (*cf.* Regionalverband Ruhr, 2009).
The analysis shows, that only about 15% of the industrial areas with different kinds of products in the Ruhr area have works sidings.
Bruckmann (2006) states that only 2% of the transport routes have company works sidings at both origin and destination, which is necessary for direct rail transportation.
Thus, a majority of firms, which produce items to carry, are excluded from direct rail transport.

1.3. Definition of combined transport (CT)

The alternative for these above mentioned companies would be a combination of road and rail. The truck transports the filled boxes to the rail terminal, the train drives to the destination terminal and then another truck brings the boxes to the recipient. This is called *combined transport (CT)*.

Figure 1: The different steps of combined transport (UIRR, 2009)

CT is defined by Seidenfus (1974) as transport of goods in loading units with different transport modes. The transition between the different transport modes is without changing the transport box.
Umbrella terms for combined transport are multimodal and intermodal transports. Multimodal means freight traffic with different transport modes as railway, road and ship and so on. This can also mean that the boxes are packed in the terminal instead. But if the transport is always in the same box, without packing it in the terminals it is called intermodal. Further detailed is what is called combined transport, which is only used, if the main part of the distance runs by railway or ship. Road transport is there kept as short as possible. The road transport from the firms to the terminals per truck is named pre- and on-carriage (*cf.* BMVBW, 2001). The only combined transport for land based transport is the rail-road version.
Due to the combination of both transport modes within CT, the firms can use the railway based transport, even if they do not have a works siding. The CT enhances the market potential of railway based transports to a large extend.
Due to the bigger potential market the following analysis of shiftable transports refers only to the CT and its aspects.

2. DEFINITION OF SHIFTABLE TRANSPORTS

Not every transport is suited for the CT. This chapter elaborates the questions, which kinds of transports are realistic and attractive to shift from an economic point of view and which kinds of goods can be or cannot be shifted from a technical point of view. Thus, some appointed minimum standards have to be fulfilled, so that a displacement can be actually proceeded.

2.1. Economic criteria depending on transport distance

The transport is a service, where the transport costs are an important point. The economical criterion means which transport mode is more economic - CT or direct truck transport. The criterion has a close correlation to the distance of the transport.
Both transport modes have different fixed costs and variable costs to cover. In the following figure, the schematic overview of the transport cost structure of each mode is shown:

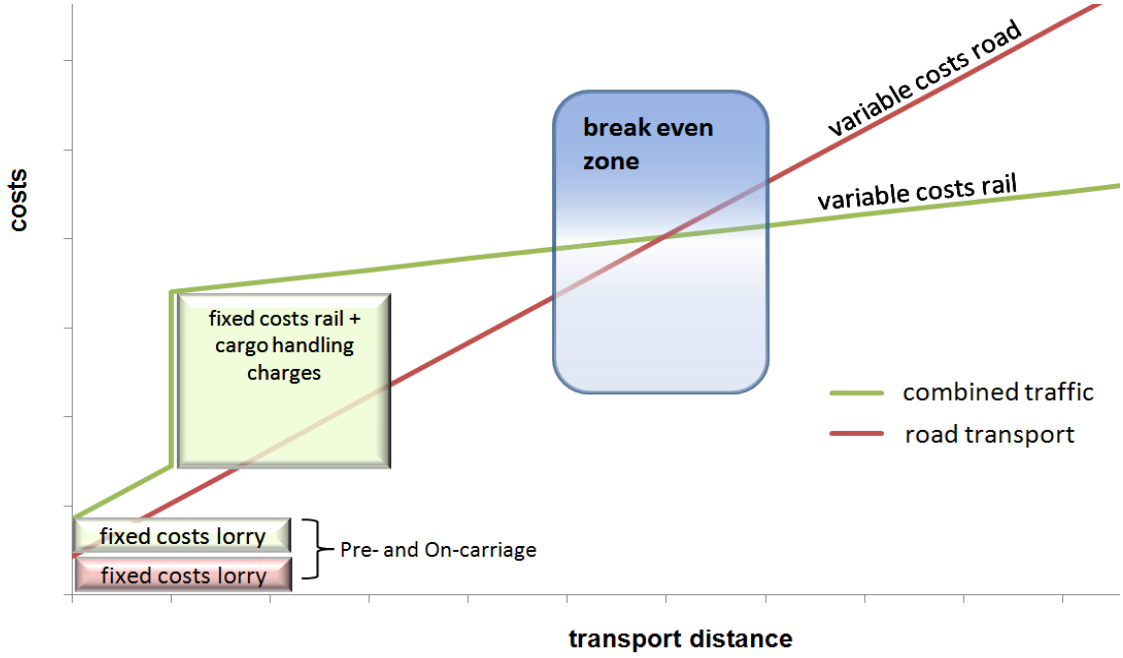

Figure 2: Schematic transport cost analysis of one truckload by direct road transport or combined traffic, depending on transport distance

CT must not only cover the costs for the train, but also for the pre- and on-carriage in trucks. The drive of the lorry from the loader to the terminal of departure is regarded as pre-carriage. On-carriage means the delivery of the freight from the railway terminal of destination to the receiving company.
The pre- and on-carriage accrue according to the distance. Therefore the costs of the trucking incorporate twice, independent of the transport distance on rail. They can be seen as fixed costs per transport.

The portion of fixed costs at the rail transport arises additionally through the cost-intensive locomotive and the costs of handling the cargo from the lorry to the train. Thus, CT has a high portion of fixed costs.
The variable costs include the electricity costs with special prices for trains, the usage of the railway lines etc., but this is just a small portion. Compared to the lorry, the variable costs of the rail transport per kilometre increase slowly.
As one can see in Figure 1, the portion of fixed costs at direct road transport is relatively low. It is basically composed out of the deduction of the lorry. High variable costs arise through the usage of fuel, which is more expensive than the energy necessary for the train and the payment of toll, which are directly related to the kilometres driven. Additionally the driver is an important variable cost factor.
For a definite distance, one can see that there is a break even zone, where the costs of the CT can be lower than the costs of the direct road transport depending on individual factors e.g. as the degree of efficiency of the train.
If the transport distance is less than the Break-Even zone, it is assumed, that the CT cannot be realised at the same or at lower price as direct truck transport.
As demonstrated in several studies (Frindik, 2007; Gudehus, 2000; Reim, Uwe, 2007; Statistisches Bundesamt, 2008; 2007; 2006; 2005; Vahrenkamp, 2005), this lowest barrier is at maximum 300 km distance.
This conclusion can be affirmed by the matter of fact, that CT is more often used at longer distances than the conventional direct rail transport between two works sidings. According to Walter (2008) the distance average in 2007 in Germany for conventional rail traffic is only 275 km whereas in CT the average distance is 493 km. This shows that CT needs longer distances to act competitively.
So, potential for the CT can only be transports which happen at distances longer than 300 km.

2.2. Technical and logistic reasons

Beside economical aspects of both transport modes, the suitability of the transported goods for CT transports has to be respected. There are on the one hand the technical conditions and on the other hand the logistic terms of CT transports.

Suitability of transport boxes depending on shifting technology
A logistic point to respect is the suitability of the used boxes for the transport of goods.
The loading to the CT happens mostly horizontal with a crane. Mobile or gantry cranes with appropriate grappler lift the box in the terminal from the parking area to the train, where it is strongly locked in place. Only containers, swap bodies or specifically strengthened semi-trailer can be handled by crane.
The horizontal loading is a special form and not possible on most of the terminals, where a complete truck goes on the train by itself. Thus, standard semi-trailer can be used, because no

handling via crane is necessary. But this special form is only offered in a small amount of terminals. All together, only these three types of boxes can be used for CT.

picture sources:
www.uirr.com;
www.krone.de
www.zlw-ima.rwth-aachen.de

Figure 3: CT suitable types of boxes (from left to right): Container, swap body and semi-trailer (special strengthened)

The members of the International Union of combined Road-Rail transport companies (cf. UIRR, 2008) carry on CT 79% container and swap bodies, 7% special strengthened semi-trailer and 14% standard semi-trailer. This refutes the definition of Reim (2007), where only containers are taken into account as potential for shifting from road to CT. The UIRR statistic shows, that not only container can be counted as technical shiftable, but also swap bodies and semi-trailer.

Another point to look into is that the change of the transport processes to CT needs different amount of effort and time.

Regarding the timeframe, container and swap bodies can easily be shifted to the CT and therefore can be counted as short-term potential. But Semi-trailer have to be specially strengthened. Therefore, the shifting needs some small investments and cannot be realised immediately, but as the effort is not very high it is realistic in middle-term.

For palletized and tied goods companies are already using semi-trailer or smaller boxes. Therefore the process and the necessary space of loading are the same as for semi-trailer and so, no major changes of the logistic process are necessary. Therefore palletized and tied goods are shiftable with relatively low effort and in middle-term.

Bulk goods are handled in a different way than palletized goods. They are not loaded into the trucks with a forklift or similar tool, but via pouring it in or out with special equipment. Thus, it is necessary to change the loading and logistic process and the equipment to adjust it to the use of container.

Additionally the companies must buy new special containers, if available, as the ones for example which are able to transport goods under pressure. The special containers are more expensive than standard containers and the investment is in the case of price-sensible bulk transport a difficult point. Therefore, bulk and special goods can be shifted maximal in long-term to the CT.

Suitability of goods depending on technical conditions

The transport goods are very different. It exist only a low amount of data to the potential to shift.

One factor is the volume of the cargo. The containers, which are accredited for railway transport, are standardised in breadth, height and length. Because of that, transport of voluminous goods, like big machines or overlong transports, for example in the steel industry, cannot be fitted in. These transports are reckoned as special load.
A second criterion is the weight. It mustn't weigh more than 44 tons for a lorry, by the transport by lorry as standard-transport in the pre- and on-carriage. Therefore for example mining products and steel transports are hardly suitable (*cf*. Bruckmann, 2006). These are transported in heavy loads or per direct transport on rails and can't be handled in container or similar boxes onto the train via crane. Therewith it can be said, that a part of the transports cannot be shifted to the CT due to abnormal dimensions. Furthermore not all bulk goods can be displaced in container and to the CT due to the weight and technical not available boxes.
Bruckmann (2006) considers these factors as well and analyzed with the help of a simulation tool the rail freight of Deutsche Bahn. The result of the simulation is that the amount of shiftable transports from the direct rail freight traffic to the combined transport in Germany covers maximum 80%. This covers bulk and special goods.
The production concept of direct railway and CT is comparable. Similar pattern can be found in the use of the railway network, longer transport time than road transports, insensibility of the goods to impacts of the train transports etc. Thus, it is here derived that no more road transports can be technically shifted to CT than direct rail transports can be. So, only 80% of bulk and special goods can be shifted to CT from the technical point of view.

2.3. Levels of potential market

The chapter showed that the distance for economically realistic shifting starts at 300 km, that the transports are technically based on three different kinds of boxes and at least 20% of bulk and special goods are technically not shiftable. Based on these results, the market potential for shifting goods from road to CT can be divided into the following levels as primary, secondary and tertiary potential.

Table 1: Levels of potential for shifting goods from road to CT

Aspect / Level	Definition	Technically	Logistically	Economically	Investment	Time frame
Primary potential	all container and swap bodies >300 km transport distances	no change of transport box	no change of loading proc-ess at the firms	possible > 300 km transport distance	none	short
Secondary potential	all palletized and bundled goods >300 km transport distances	adjustment of transport boxes	small/ no changes of loading proc-ess at the firms	possible > 300 km transport distance	small	middle
Tertiary potential	80% of bulk and special goods >300 km transport distances	max. 80% shiftable technically in CT trans-port boxes	Reorganisa-tion of loading process at the firms	possible > 300 km transport distance	middle (for boxes and loading technique)	long

3. CALCULATION OF SHIFTABLE ROAD TRANSPORTS

3.1. Types of freight

The German Federal Statistical Office Kraftfahrt–Bundesamt (2008) releases data on the annual traffic volume of road transports by type of traffic. The total volume in 2007 has been about 250 millions lorries on German roads including transit transports. Bulk and special goods, which have only been defined as tertiary range to shift to CT, represent more than half of the total volume. The primary range of potential is container and swap bodies; they only represent a share of about 20% of the total volume.

Table 2: Traffic volume of German road transports 2007, according to types of freight (based on Kraftfahrt-Bundesamt (2008))

	Type of freight	Number of lorries		Proportion
Primary range	Container / swap bodies till 6m	29.946.500	**52.092.200**	**20,6%**
	Container / swap bodies above 6m	22.145.700		
Secondary range	palletized goods	60.778.300	**69.491.300**	27,5%
	tied goods	8.713.000		
Tertiary range	fluid bulk goods (not packed)	15.257.500		
	arid bulk goods (not packed)	71.791.300	**131.174.300**	51,9%
	Special goods	44.125.500		
	Sum	252.757.800	252.757.800	100%

3.2. Transport distance

The transport distance is one of the most important criteria for shifting transport to the CT, which is a minimum of 300 km.
To determine the shifting potential, the values of container transport were used.
The German statistical office Statistisches Bundesamt (2005; 2006; 2007; 2008) has published the annual figures on lorry transports volume by distances for Germany since 2003. The percentage of transports longer than 300 km can then be estimated.

Table 3: Annual container transport by lorry according to distances (calculation based on Statistisches Bundesamt, 2005; 2006; 2007; 2008)

	Transport distance < 300 km		Transport distance > 300 km	
Year	Amount TEU[1]	Percentage	Amount TEU	Percentage
2003	9.675.000	86,3%	1.534.000	13,7%
2004	9.572.000	86,1%	1.551.000	13,9%
2005	11.071.000	87,6%	1.560.000	12,4%
2006	12.483.000	88,9%	1.566.000	11,2%
Ø Average	10.700.250	87,2%	1.552.750	12,8%

As one can see in Table 3 the percentage of transports over 300 km varies between 11,1 % und 13,7 %. One can observe a slightly negative trend in the last three years, whereas between 2003 and 2004 an increase took place; therefore an obvious trend cannot be identified. Using the average amount over a number of years shows a more significant evaluation. The average amount is 12,8% of the annual container transports.
This means that nearly 90% of container transports are not suitable for combined transport at all.
Containers carry usually similar goods as swap bodies or semi-trailer as for example pallets, tied goods etc. for the transport between two production areas or warehouses. Consequently, there would be a similar share at the transport distance over 300 km.
Other goods as bulk and special goods have a different system and therefore do not have the same share according to the distances. Only 9,4% of all trucks in Germany in 2007 carried the goods over 300 km (Kraftfahrt-Bundesamt, 2008). This percentage is considered as the maximum share of bulk and special goods carriages for distances over 300 km.

[1] The unit TEU (Twenty feet Equivalent Unit) stays for one 20 feet container, two 10 feet containers or a half 40 feet container. TEU is used as a standard measure in the sea cargo.

3.3. Calculation of maximum potential

In combination of all previous analysis, the calculation of the maximum potential of shifting potential can be done. The following table shows the calculation. The amount of German truck transports per freight category in 2007 is used as basis. Then, only transports with a distance longer than 300 km and which are technically able to be shifted are counted.

Table 4: Calculation of maximum shifting potential

	Type of freight	Number of transports 2007	> 300 km distance	Technical shiftable	Potential	Proportion of total volume
Primary potential	Container / swap bodies	52.092.200	12,8%	100%	**6.657.400**	**2,6%**
Secondary potential	Palletized and tied goods	69.491.300	12,8%	100%	**8.881.000**	**3,5%**
Tertiary potential	Bulk goods and special goods	131.174.300	9,4%	80%	**9.895.800**	**3,9%**
	Sum	**252.757.800**			**25.434.200**	**10,1%**

The primary potential, which is workable in short term has a maximum of only 2,6% of all truck units. In addition, the technical and economic analysis concludes that only 7,4% of the freight volume traffic of the secondary and tertiary levels can be shifted from road to CT.
The results of the market analysis are shown in the following figure. The main point is that about 90% of all direct truck transports can definitely not be shifted.

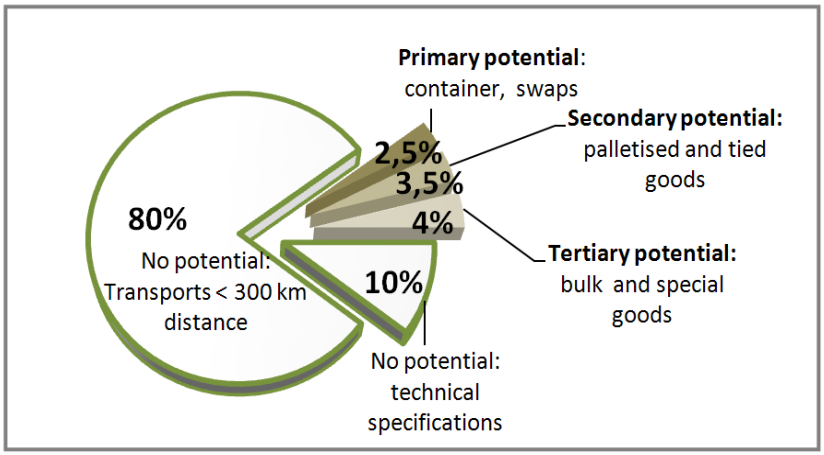

Figure 4: Summary of German truck transports 2007 and their potential to shift to CT

3.4. Increase of transport volume in comparision to current market

A maximal shifting potential of 10% (with a primary potential of 2,6%) sounds very low at first sight. But looking at the existing amount of transports the number appears much higher.

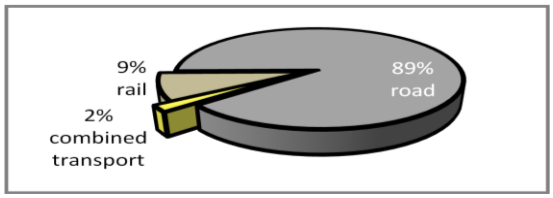

Figure 5: Share of land based transport modes 2007 in Germany (cf. Kraftfahrt-Bundesamt, 2008)

In 2007 the combined transport carried about 70.000 tons in Germany, which account for only 2% of the total land based transport volume. The share of road transports is about 89%. As the share is only available in tons, a translation is necessary, to count the maximum possible increase.

Table 5: Theoretical increase of CT - quantity, in the case of shifting all potentials (calculation based on Kraftfahrt-Bundesamt (2008) and Table 4)

	Ø tons per lorry	Potential in loads	= Potential in tons	Increase
Combined transports 2007 in tons			70.147.000	
Primary potential	4,5 t - 7,0 t	6.657.383	+ 37.158.566	
			107.305.566	**53,0%**
Secondary potential	10,5 t -12,5 t	8.881.000	+ 95.606.354	
			202.911.920	**189,3%**
Tertiary potential	10,3 t - 17,8 t	9.895.800	+ 150.057.096	
= Maximum			352.969.016	**403,2%**

So, in case of shifting all primary potential to CT, the volume of CT would increase for about 53%, taking into account the secondary potential this would be together an increase of 189%. Considering the maximum shifting potential, this represents five times more than the current amount in 2007.

4. CONCLUSION

It is a political requirement to reduce CO_2 production for ecological reasons. This paper has shown that combined transport (CT) enables companies to transport their goods on the main route via the CO_2 friendly train.

The economical suited road transports, which can be potentially shifted from road to CT, have been defined as long-distance transports (> 300 km). The technical suited potential is the type of goods, which can be transported in boxes like containers, semi-trailer or swap bodies.

In total, the shifting potential results are

- primary potential: 2,6% of the truck transports can be shifted in short-term,
- secondary potential: 3,5% in middle-term and

- tertiary potential: 3,9% in long-term.

This implies the absolute maximum market potential for the CT covering only 10% of the actual truck transport market. Almost all truck transports (90%) are not suitable for combined transport.
But, in relation to the current status, the shifting of the total potential to CT will result in five times more traffic on the CT than at present time.
Therefore, there is a lot of potential left for the CT. However, other solutions for the remaining 90% of the truck transport market, which are not shiftable, must be found in order to reduce the CO_2 production appreciably.

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