Understanding CO_2 reduction and efficiency in road freight transport and logistics. German surveys and case studies 2002-2005

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Abstract

Since 2002, numerous case studies have investigated the sustainability effects of efficiency measures in German road haulage companies. Particular focus was set on the impacts of the company measures "scheduling systems" and "introduction of on-board telematics" and on the sector analysis for the efficiency improvements in Courier, Express and Parcel (CEP) services. The purpose has been to arrive at further insights into the energy efficiency issues in those fields of business which have until now remained largely unexplored. One objective is to gain understanding of the mechanisms of various processes, which influence efficiency and create new framework conditions; qualitative investigations were carried out to this end. To tackle the lack of data, it is necessary to quantify the current efficiency values at the company level, so that company decision making can be based on them. The aim is to discover whether the decoupling of freight traffic from energy consumption is taking place at the business level and to investigate the potential for further steps in order to be able to make policy and company related recommendations.[1]

Keywords: *CO_2 reduction, energy efficiency, freight transport, decoupling, surveys, case studies*

Résumé

Une enquête sur les transports routiers a permis de collecter des données dans plus de 200 entreprises allemandes et de relier la consommation d'énergie aux paramètres de performance du transport. L'efficacité énergétique a été analysée pour les mesures « systèmes de gestion et planification des tournées » et « télématique embarquée », ainsi que pour le secteur des messageries. Les résultats montrent un potentiel d'amélioration à cause du niveau assez bas du taux d'utilisation des véhicules, du faible nombre de camions à carrosserie légères, et d'un taux élevé de transports à vide. Le découplage entre la performance économique (PIB national), les distances parcourues et les émissions de gaz carbonique par camion, a été montré dans plusieurs études de cas. Des recommandations pour la prise de décision sont dérivées des analyses et des résultats des enquêtes.

Mots clés: *Réduction des émissions de CO_2, efficacité énergétique, transport de marchandises, découplage, enquêtes, études de cas*

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[1] This article is the short version of a study co-authored by Michael Baumgartner and Oliver Krusch in the context of the projects NESTOR and NESTOR2 at the Max Planck Institute for Meteorology in Hamburg. This is an original contribution.

Trends in decoupling and the example of Company C

Road freight transport growth is, in terms of turnover, coupled with GDP growth in Germany. In terms of tonnes (volume) or tonne-kilometres (performance), the growth is only partially coupled with GDP. Since fuel use is slowly declining in road freight, a weak decoupling of climatic impacts from freight growth has been observed since 2001. The drivers of road freight growth in recent years in Germany have been demand growth due to globalisation and the opening of Eastern European markets, growth absorption only in the road and not in the rail sector (due to the low competitiveness of German rail freight), reduced parcel size, an increasing demand for cabotage, etc. The drivers of reduced fuel use (and a slight reduction in CO_2 emissions) have been the new tax and higher fuel prices, improved engines and goods vehicle design, slightly improved load factor, and more generalised use of traffic telematics.

Transport performance data and fuel consumption data were recorded by onboard systems on 60 trucks in one general cargo company, chosen for its business practice "normality" for one case study survey in 2005. A net CO_2 reduction per vehicle has been demonstrated for the years 2001 to 2004 (figure 1). Calculated were standardised mean quarter values, allowing a comparison with GDP data from the national statistics. In this period, mileage per vehicle is continuing to show a slight increase, but less than GDP growth. These results on decoupling are not contradictory, but complementary to the results from Finland (Tapio, 2005), Denmark (Fosgerau and Kveiborg, 2004) and UK (McKinnon, 2003).

Figure 1

The empirical survey of CO_2 efficiency in freight: the aim of the general survey (January to May 2003) was to investigate the state of the art in CO_2 efficiency and the available potential for optimisation in the German road haulage sector. The results of the data collection in a randomly chosen German sample is a set of 153 coupled data, representing 2-4 days complete and exact tkm and fuel use records, and a total performance of more than 1.6 million tkm. These data are showing that the CO_2 efficiency of the transports fluctuates from 0.8 to 26 tkm per kg CO_2. A close correlation exists between efficiency of vehicle use (tkm/total mass-km) and CO_2 efficiency (figure 2). Further influencing factors for efficiency are load capacity utilisation rate, vehicle size, and payload/dead weight ratio. Empty mileage, size and sector of the business are less strongly correlated to CO_2 efficiency.

Figure 2

The market share of CO_2 efficiency measures was determined for 52 German companies. According to these figures (Leonardi and Baumgartner, 2004), only a few successful technological and other measures like driver training have been introduced across Germany in logistics and transport companies. The potential for further improvements in efficiency is high, and the possible short term CO_2 reduction has been estimated at 20% of the total current emissions generated by road haulage.

Efficiency in the CEP sector and for a company case: the market for CEP services is growing in Germany, and the potential for efficiency improvements lies with the vehicles themselves and the company organisation. The use of gas-powered vehicles, IT-supported scheduling optimisation, driver training, and many other measures have a potential. Application barriers have been identified in the form of the limited financial resources available for new decisions on the side of self-employed drivers and in the low level of interest shown by company central offices in making sure, through organisational means, that the fleet is used in the most energy efficient way. The reason for this is that the extremely demanding time conditions for parcel delivery in the CEP sector implicates that all the attention focus on time efficiency in the daily business. Efficient vehicle use is not a priority. The use of one car for delivering a single parcel with an average weight of 5 kg is a common

figure. In the case of the German company GO! (3000 vehicles), 48 distribution trips, 24 collection trips, 53 direct transport trips and 14 night line deliveries were surveyed in March and April 2005. Questionnaires gives values on parcel number, mileage, vehicle characteristics and fuel consumption of each trip. Each trip dataset obtained allow the calculation of the key variables for energy efficiency. The mean vehicle consumption is around 8 l/100km. The best car used 4,5l/100km and the least efficient one about 14 l/100km. City trips vary from 45 up to 530 km per day. Hub transports are about 6 to 700 km per night. The lowest average efficiency value is around 0.57l per parcel for a nationwide shipment. This is a low value, which shows that a high level of efficiency can be achieved for parcel shipments in CEP logistics. However, the detailed analysis of trips efficiency, differentiated by the business sub-sectors of the company, allows the identification of areas with a high potential for further improvements. Especially high efficiency potential exist for "direct courier" delivery for the case, where a single parcel has to be directly sent by car from the customer to a far distance destination. For such cases, occurring often in the day-to-day business, a factor 60 between the most efficient and least efficient day average is a clear indication that solutions for efficiency improvements are worth to be tested and implemented.

Scheduling software and telematics: it was demonstrated that, when the load volume remains constant, the CO_2 efficiency of a road haulage company improves by about 10% upon introduction of an IT-supported scheduling system (Leonardi et al. 2004).

Technologies and markets are very complex and therefore not transparent in terms of cost-benefits analysis or environmental cost-effectiveness. One assumes that the companies should have a financial interest for investments in new technologies allowing a better efficiency performance. This argument is only partly validated by the interviews with 20 decision makers in transport companies and software producer. Due to the lack of cost benefit examples, decision maker in companies are reluctant to invest in systems with complicated handling and relative high prices (2000-5000 euro/truck). The identified efficiency potential is depending on the low German average of 49% load factor in 2003-04. Our case study with onboard telematics indicates an even lower mean value of 44% load capacity utilisation.

The main question for further developments is, to what extent IT scheduling and telematics systems could be improved ? Users frequently mentioned as desirable such points as a greater degree of integration between the various IT supported scheduling and telematics systems for data communication and location, as well as improvements in the stability of the on-board telematics components. Further improvements could be achieved through filling the technological "missing link" between data communication devices and on-board-monitoring (CAN-bus) systems. This could be done by creating interfaces between IT scheduling and on-board monitoring systems, the automatic measurement of volume capacity utilisation, and an improved or more widely used semi-automated route and run optimisation system.

A small case study on the implementation of the Logiplan software in a company shows a reduction of 16% in distance covered with the same load after the introduction of the new scheduling and tour planning system. Therefore, a high level of market potential for IT scheduling and telematics is given. The need for simplified technology and transparent market information is also high.

Policy analysis: Instruments, solutions and measures proposed for decoupling

One of the main points of the dialogue with various German decision makers interviewed in the years 2002 to 2005 was the policy dimension and the future improvement of the efficiency potential in freight transport. Many instruments were identified, having a high potential for lowering total fuel consumption in road freight. The principal solutions improving the market diffusion of efficiency measures in companies or at the level of entire supply chains are:

- Information campaigns and diffusion programmes for all technologies and organisational measures such as telematics systems and technologies, aiming at enhancing the goods vehicle load factor and lowering the emissions per tonne kilometre or per unit (parcel or pallet), (e.g. in the context of a freight energy efficiency campaign).
- Cost-revenue examples show that, in some cases, a return on investment in efficient technologies and organisational measures is possible within a few weeks for a trucking company. To spread such cost-revenue examples, a kind of free accessible European best practice catalogue should be started. To ensure independency and impartiality in cost-revenue analyses for efficiency measures, the aid of independent public agencies is needed. Only then, efficiency analysis could become part of the strategic thinking of company decision makers. Transport agencies, energy agencies, environmental agencies or city authorities could be actively linked. This would help to overcome one main market barrier: the lack of product and service transparency due to a very large amount of suppliers and concepts on the market.
- Further independent technology tests and evaluations of performance under real road traffic conditions are required, aiming at measuring energy efficiency gains for each type of technology and each sub-sector of activity. The test results should be available to the companies. Objectives here are
    - the improving of the information base for decision-making,
    - the lowering of the risk of investments and
    - the improving of the application rate of efficiency technologies in Europe.
- Further needed is the effective harmonisation of driver regulations and goods vehicle control practices with, for example, the introduction of a digital tachograph.
- Driver training programmes and promotion of eco-efficient driving techniques. As it is a fact that driving courses are generally not well attended because of the loss of at least one business day, some incentives are required here. The main barrier to implementation is the high time pressure in the sector. Cost-free training courses offered by vehicle manufacturers - for example, at the point of purchase of a new truck - should include energy efficient driving techniques and become a further generalised practice.
- Research and Development on goods vehicle technologies such as fuel switch (biodiesel, CNG etc.), on-board telematics, light vehicle design, improved engine performance (for all vehicle types, not only heavy duty trucks) etc.
- Market studies on following topics (among other):
    - diffusion of innovative technologies,
    - restrictions on, and possibilities for, the different logistics concepts aiming at efficiency improvements,
    - solutions for overcoming the market barriers.
- Modal change: Improve the competitiveness, reliability and speed of rail freight transport system and rail-road intermodal structures. The objective is a substantial increase in the demand for long-haul rail freight.

Effects of instruments and measures proposed

Positive market development and environmental effects are expected from a further implementation of existing measures, such as road pricing, and also from future efficiency measures (technologies and organisation) such as on-board systems, IT-disposition and telematics, fuel switch, new co-operative agreements etc.

There are no potentially negative effects of the proposed measures on the road haulage and logistics sectors in terms of business turnover growth. For the side of the shipper from industry and trade, the logistics service quality can only improve and therefore growth conditions can only be positively affected.

Most of the proposed measures require very low cost for the state and the authorities. A significant decrease in total fossil fuel demand will affect the oil industry, only if its decision-makers are not actively developing alternative fuels and not improving the market diffusion of renewable energy sources on their own initiative.

However, the other drivers for logistics market development like globalisation and rapid growth in NMS could induce some possibly negative effects, and counteract the effects of the measures, for example through a strong increase in total vehicle fleets and an unexpected growth in international (European) demand for road freight in terms of mileage.

Policy recommendations

- Implement the measures and technologies proposed above
- Strengthen the decision making process and develop the information base for energy efficiency in road freight transport, with the help of public relation campaigns, thus giving impetus for new company policy directions. It is also necessary to change some regulatory frameworks.
- Help internalise at least partially the external costs from the road freight transport sector and improve the ecological effectiveness of fuel tax and other fiscal instruments. Reinvest at least a part of the fuel tax revenues (and the revenues from other fiscal instruments such as road user charges) into measures and technologies proposed and into accident prevention and safety measures.
- Promote collaborative socio-economic research on energy efficiency in the freight transport sector in OECD countries (improve research co-operation between European, North American and East Asian research institutions in this field).

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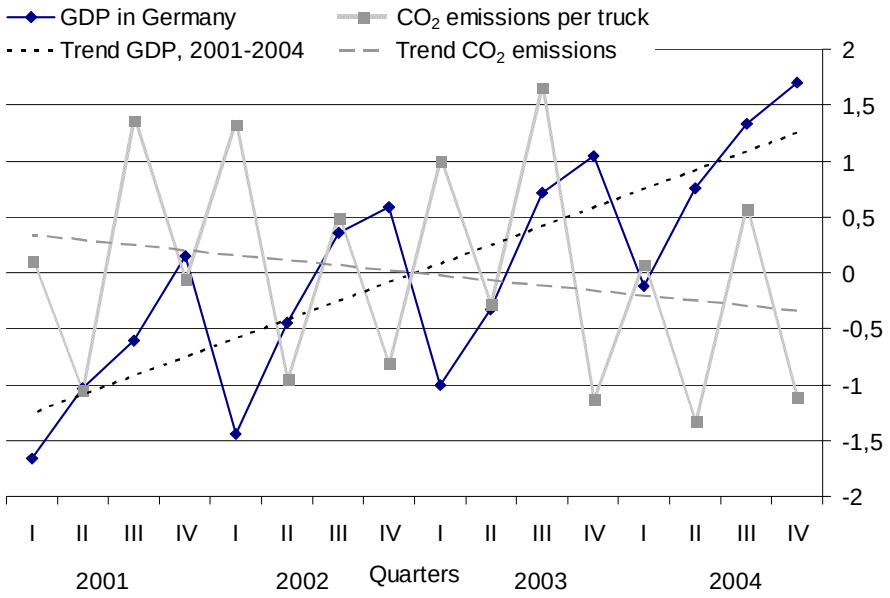

Figure captions

Figure 1: **GDP in Germany and CO_2 emissions per heavy duty truck in Company C, 2001 to 2004** Quarter means from telematics data recorded by 60 trucks; from: Stat. Bundesamt 2005, survey NESTOR

Figure 1: *PIB en Allemagne et émissions de CO_2 par véhicule poids lourd dans l'entreprise C, de 2001 à 2004; Stat. Bundesamt 2005, enquête NESTOR*

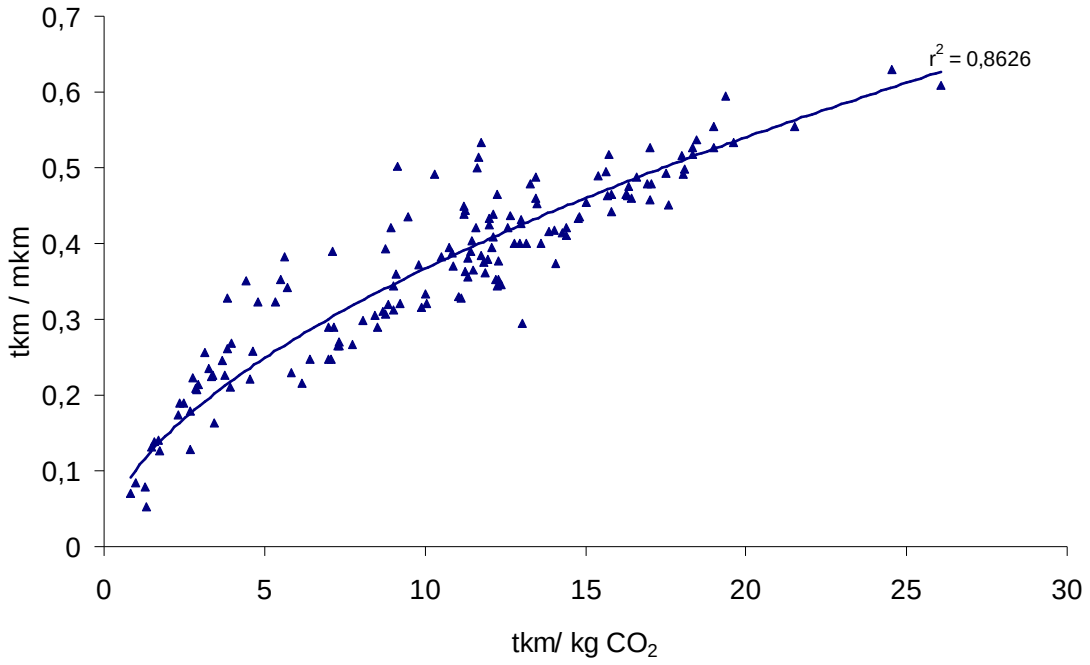

Figure 2: **Average values for the surveyed 2-4 days: trips performance, efficiency of vehicle use and CO_2 efficiency;** from: survey NESTOR

Figure 2: *Valeurs moyennes pour les trajets de 2 à 4 jours: performance, efficacité de l'utilisation des véhicules et efficacité énergétique; enquête NESTOR*