Assessing the impacts of automation on national freight transport – A case study for Germany

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Abstract. Freight transport emits a high percentage of our global industrial carbon dioxide, which is a main factor of today's global warming. Any reduction of the carbon dioxide emission reduces negative effects on the global climate. Focussing on this challenge, we analyse the influence of automation on mode and road mean choice at the German level. For assessing the impacts of the automation, we use a macroscopic freight transport model for Germany. The automation will be modelled in 2 scenarios, which are focused on autonomous road freight transport. The scenarios are compared with the corresponding baseline scenarios in 2030/2040.

1 MOTIVATION AND OBJECTIVES

The European and German freight transport is challenged by several new situations: (i) increasing global economy, (ii) predominance of oil-depending transport means as well as (iii) its greenhouse gas (GHG) emissions. The aim of Germany is affordable goods for everyone in a strong Single German Market as well as an ecological freight transport in Germany. For this reason, we will analyse two scenarios which project two degrees of autonomous road freight transport: in the year 2030 and 2040. By our macroscopic freight transport model DEMO-GV, we will show the impacts of these two scenarios. DEMO-GV projects the mode choice on the three transport modes 'rail', 'road' and 'inland waterways' (iww). Additionally, the model projects the mean split on road, corresponding to the truck types.

2 GERMAN FREIGHT TRANSPORT MODEL DEMO-GV

We use our German macroscopic freight transport model 'DEMO-GV'. By this model, we calculate the freight transport demand in Germany differentiated into the transport modes 'rail', 'road' and 'inland waterways' (iww) in 2030/2040. This model is a 4-step approach which includes freight generation, distribution, modal split and transport means split. Depending on the average transport costs on the three modes, we derive freight transport volume and performance between 431 German and 170 foreign European traffic cells. The freight demand is differentiated into commodity groups according to the classification NST 2007. The model 'DEMO-GV' can be configured by different transport costs on 'rail', 'inland waterways' and a flexible number of vehicles types for road freight transport. In the following, the 4-step approach of DEMO-GV will be explained in detail.

Step 1: Freight Generation
Depending on forecasted added values (in euros) for each traffic cell for the forecast year 2040, the supply and the use of each commodity in each traffic cell is calculated. Especially, value-density of each commodity is used [1]. In the end, there is the freight transport volume in every cell as source and sink.

Step 2: Distribution
The relations between the sources and sinks of the generated freight transport volume will be determined by an 'iterative proportional fitting', using the 'gravity model of trade' between source and sink.

Step 3: Modal Split
Based on the costs for an average delivery between source and sink of the three modes for a commodity, we calculate the utilities for all three modes (BVU [2]). The utility u represents the value of a freight transport from the origin (source) to the destination (sink) with the specific mode, corresponding to the logit model [3]:

$$p_i = \frac{\exp(u_i)}{\exp(u_{rail}) + \exp(u_{road}) + \exp(u_{iww})} \quad (1)$$

p_i is the probability for the transport of an average delivery between origin and destination cell for each mode i. If transport volume tv is the total mass which is transported between origin and destination of a commodity, tv_i is the mass which is transported with mode i between these two cells (modal split):

$$tv_i = tv \cdot p_i \quad (2)$$

All utilities are calibrated by the modal splits of 2010.

Step 4: Mean Split

The transport volume tv_{road} which is transported on the road can be differentiated into different truck types. We use EUROSTAT data [4] for estimating the parameters for each truck type for a maximum likelihood model (probability p_{mean}). This probability provides the transport volume tv_{mean} which is transported by a specific truck type (mean split) between origin and destination cell:

$$tv_{mean} = tv_{road} \cdot p_{mean} \quad (3)$$

The truck types depend on permissible total weight (ptw):

- Truck 3.5 ≤ 7.5 t ptw
- Truck 7.5 ≤ 12 t ptw
- Truck 12 ≤ 18 t ptw
- Truck 18 ≤ 26 t ptw
- Truck > 26 t ptw

3 SCENARIO DEVELOPMENT AND EXPECTED RESULTS

Results for the year 2010 and for the baseline scenarios in the years 2030 and 2040 already exist. In the framework of this project, we develop two scenarios for the forecast years 2030 and 2040: ‘Multimodality’ (M) in 2030 and ‘Multimodality+’ (M+) in 2040.

The scenario ‘Multimodality’ assumes the use of platoons in main leg on highways between hubs. The hubs can be used for multimodal or monomodal transport. The commodity which will be transported on automatized road transport is mainly groupage freight (system traffic and seaport hinterland traffic).

The scenario ‘Multimodality+’ is an extension of scenario ‘Multimodality’, when automation will probably be gone further. We assume driver-less trucks for the observed freights. Further, the transhipment technology at hubs shall be automatized. This leads to a transhipment time reduction by – 50 %, for all commodities.

Both scenarios assume an automation on road-vehicle trucks with (just) > 20 t ptw. This leads to a fuel consumption reduction by -3 %, which increases u_{road}, equation (1).

References

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