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Combining Macro- and Microscopic Approaches to Model Commercial Transport Demand in an Urban Area

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Abstract

Demand modeling of commercial transport has lagged behind private passenger demand modeling as a result of insufficient data sources and the complex types of movement. At a supra-regional level, commercial trips are usually conducted by heavy trucks. However, studies in urban areas show that only about 40% of all commercial trips are conducted by heavy vehicles, while the other 60% is conducted by light vehicles, indicating that this is not freight travel. Even though commercial transport has been somewhat regarded in recent research, most models focus on either freight trips or trips conducted to provide a service. However, for assessing policy sensitivity, all parts of commercial transport need to be considered.

The model we present regards all aspects of commercial transport by assessing the parts separately. We distinguish between vehicles with variable and fixed daily. We further differentiate vehicles with fixed daily schedules into vehicles with short and long supply chains while focusing on the latter. To regard the entire supply chain of delivery vehicles we a combined macroscopic approach to obtain transit flows on a European level with a microscopic approach that is used to distribute the obtained packages of an urban area within said areas. The results of both the macroscopic and microscopic parts of the model are compared to traffic count data. The comparison of values show that the combination of macroscopic and microscopic model parts can model vehicles of commercial transport with a long supply chain, however, more attention should be regarded to the microscopic distribution.

Keywords: Commercial transport, demand modeling, delivery services, microscopic, macroscopic

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1. Introduction and Motivation

Commercial transport adds a significant amount to the total traffic volume. However, it has often been disregarded within the modeling context and lags behind passenger transport modeling, even though 10 – 15% of urban traffic volume can be attributed to commercial transport. Nonetheless, to model a region's transport demand properly, it should not be reduced to passenger transport only. Even though about 60% commercial trips in urban areas are conducted by light vehicles (Hunt et al. 2006), commercial transport demand models are often reduced to freight transport, as this is already a challenging modeling field. In urban areas, freight modeling has been gaining significance as e-commerce demand is increasing. According to the Statista Digital Market Outlook, the total revenue in e-commerce is increasing, regardless of the considered region. In China, an increase of 91.6% is expected by 2022. In Europe, an increase of 46.4% and in the US an increase of 56.0% is predicted by 2022 (Statista DMO 2018). It can be assumed that this would result in a decrease in total traffic volume, as people switch from conventional in-store shopping to online shopping and therefore conduct fewer trips. However, this would only result in a shift in personal shopping trips to commercial delivery trips. Furthermore, studies show that online shopping does not lead to a replacement of in-store shopping trips, but that there is a relationship between the two means of shopping and that online shopping does not replace in-store shopping trips by the customer (Lee et al. 2017).

The aforementioned increase in e-commerce and the interdependence of online and in-store shopping highlights the importance of an integrated model of both private and commercial transport. However, combining both private and commercial transport demand models is challenging due to the lack of data, especially for commercial transport. Therefore, the first step towards an integrated model is to model private and commercial travel demand – including delivery trips – separately. However, both approaches should model travel demand on a microscopic scale as the interdependence of private and commercial transport require a high level of detail, so the future integration of both models is possible.

In this paper, we present an approach to combine results of a large-scale, continent-wide macroscopic model with an urban, microscopic commercial transport demand model. We first present relevant literature regarding commercial and freight models, after which we present the macroscopic data as well as our microscopic model approach and the method to combine them. We then describe how we implemented the combined model and subsequently we present the results of this implementation. We finalize our paper with a conclusion and discussion section of our findings.

2. Literature Review

Choice situations of actors in commercial transport differ a lot from those of private passengers. Commercial travel demand is highly dependent upon the demand for commercial services, be that the transportation of goods or the provision of a service by artisans. Furthermore, actors of commercial transport also differ when comparing them in a regional context. At a supra-regional level, commercial trips are usually conducted by heavy trucks. However, studies in urban areas show that only about 40% of all commercial trips are conducted by heavy vehicles, while the other 60% is conducted by light vehicles, indicating that this is not freight travel (Hunt et al. 2006). For this reason, most commercial transport models focus on modeling urban vehicle movements. One such model is presented by Stefan et al. (Stefan et al. 2005), in which the authors present a model of commercial vehicle movements in Calgary, Canada. The model includes all types of vehicles, ranging from light commercial vehicles to heavy trucks. However, the focus is on tour-based movements, usually conducted by light vehicles, leaving the internal-external and fleet-allocator movements to be modeled only rudimentarily. Based on the model proposed in Calgary, Canada, Ferguson et al. (Ferguson et al. 2012) have adopted the model and modified it for it to be applicable to the Greater Toronto and Hamilton Area in Canada . Another microscopic approach to model commercial travel demand is presented by Gliebe et al. (Gliebe et al. 2007). The proposed model only includes intra-metropolitan commercial travel, disregarding vehicles operating on fixed routes and commodity transport within a broader regional context.

The models mentioned above all model part of urban commercial travel on a microscopic level. However, commodity transport is regarded only rudimentarily or not at all. This underrepresentation can be explained by the fact that the freight system itself is already very complex and many detailed approaches have been presented to model it. Commodity or freight transport models can be divided into two groups of models: commodity-based and tour-based or vehicle-based models. Commodity-based models usually use matrices of the origin and destination (OD) of goods and then convert the quantity of goods to vehicle units. An example of such a model on a microscopic level is presented by Wisetjindawat et al. (Wisetjindawat et al. 2007). Examples of commodity-based models include those presented by Müller et al. (Müller et al. 2012) as well as Rwakarehe et al. (Rwakarehe et al. 2014). Tour-based or vehicle-based models have also been presented on both a microscopic and macroscopic level. Kulpa presents an example of a macroscopic vehicle-based model (Kulpa 2014). Microscopic vehicle-based models are presented by Schröder et al. (Schröder et al. 2011) and Joubert et al. (Joubert et al. 2009).

The presented literature shows that until now only certain aspects of commercial travel demand has been regarded in the respective models. Models either tend to focus on commercial trips conducted by light vehicles, paying little attention to freight transport or they disregard service trips and only focus on freight transport. However, to adequately model commercial travel demand, all commercial sectors need to be taken into account. Furthermore, the regional context plays a significant role, and due to their interdependencies, the different actors of commercial transport have to be modeled together to represent all commercial trips accurately.

3. Data and Model Approach

Demand modeling of commercial transport has lagged behind private passenger demand modeling as a result of insufficient data sources and the complex types of movement in commercial transport. For example, the movements of goods show different characteristics than the movement of artisans conducting trips to perform a service.

Due to this difference in behavior, our approach for modeling urban commercial movements is separated into different parts. We have divided the model into vehicles with fixed daily schedules and vehicles with flexible daily schedules. We furthermore distinguish between vehicles with different radii of action of the travel demand. Vehicles with flexible daily schedules include craftsmen, insurance agents, construction managers, sales representatives and the like. These mentioned industry sectors usually limit their businesses to certain areas and often do not cross municipal boarders. The same applies to business where vehicles are mainly used with fixed daily schedules. The daily routine of care services, garbage trucks, and mail delivery services does not vary much and has mostly one main activity purpose, and they, too, stay within the same area of operation. This is different for vehicles of courier, express, and parcel(CEP) delivery services. Even though they follow the same basic schedule every day (e.g., loading trucks and delivering packages in pre-assigned areas), the source of the cargo they carry lays mainly outside the delivery area. In this chapter, we describe the different modeling parts, focusing on economic sectors with a long supply chain. Therefore, the implementation was carried out only for this part of the model and the results presented in the subsequent chapter are limited to tours of CEP-delivery services. In (Reiffer et al. 2018) a detailed description of the microscopic approach for the other model branches and behavior types is presented.

3.1. Vehicles with variable daily schedules

Vehicles with varying daily schedules do not have a predefined set of stops on one day and the next stop is determined iteratively. Such vehicle usage is typically caused by craftsmen, insurance agents, construction managers, sales representatives and the like.

Transport demand models are usually based on household surveys and trip diaries. These often only regard private trip purposes to full extent and comprise commercial trip purposes into only one trip purpose. This is why previous approaches to model commercial travel demand have been widely based on surveys specifically conducted for the respective model. This approach leads to the fact that the model is only applicable in the region where the survey was conducted. To avoid this, we used the mobility study “Kraftfahrzeugverkehr in Deutschland” – KiD (Motor Traffic in Germany), a survey conducted in 2002 and 2010 (Wermuth et al. 2012). The goal of this study was to conduct information on commercial transport, focusing on light vehicles. The data consists of four data sets, one on vehicles, one on trips, one on trip chains, and on geographical data. For this study, vehicle owners or drivers were asked to give information on their vehicles and report trips taken on the reporting date.

The described data was first used to perform a clustering analysis to find out if vehicles of a certain size behave similarly. An aggregation of vehicles to groups of different sizes has been suggested in the relevant literature (Gliebe et al. 2007; Stefan et al. 2005), however, without presenting any analytical approach. For the clustering analysis, we first aggregated the data to small groups based on industry sector and type of vehicle. KiD 2010 differentiates nine vehicle types and 21 industry sectors, yielding 189 small groups. In order to avoid distortion due to few data entries within a small group, we withdrew small groups with less than ten entries. We used linearly independent characteristics that best describe a vehicle's daily behavior:

- Number of trips,
- Daily mileage,
- Duration of trips and
- Start time of the first trip.

Using these characteristics of the aforementioned data, we first used the single-linkage approach, a method that works well when wanting to identify outliers (Bacher et al. 2011). After detecting and removing the outliers from the data set, we used the ward method to identify homogenous clusters. This cluster analysis yielded results that comply with the vehicle groups suggested in the literature. The clusters we found were

- Light vehicles: Passenger cars, trucks up to and including 3,5t,
- Medium vehicles: Trucks over 3,5t and Busses and
- Heavy vehicles: Semi-trailer trucks.

For vehicles with varying activity purposes, the model first determines what kind of activity is to be pursued and subsequently a place for carrying out the determined activity is identified. The possible trip purposes were chosen according to the ones used in KiD:

- Pick up, delivery, transport of commodities, goods, materials, machines, appliances, etc.,
- A trip to provide a service (assembly, repair work, consulting, visit, care, etc.),
- Pick up, drop off, transport of passengers (commercial),
- Other commercial/business errands and
- Return to the business establishment.

Using these trip purposes, we modeled the next trip purpose by applying a nested logit model to the data. A nested logit approach was chosen over a multinomial logit approach to comply with the independence of irrelevant alternatives (IIA). Workers first choose, if they are going to make another business stop or if they are either conducting a private trip or a trip back to their business establishment. Only if the choice is to make another business stop, the choice model determines which specific purpose. If a multinomial logit were applied, private trips and trips to return to the establishment would be preferred over conducting a commercial trip. For each trip purpose, a utility function was determined and applied.

The data basis used for modeling activity choice has not proven to be effective for modeling destination choice, as neither information on the choice process nor geographical information about the destinations and their alternatives was available. Due to these difficulties, we chose to model the destinations of previously determined activities depending on the economic sector of the vehicle and the activity purpose.

3.2. Vehicles with fixed daily schedules

For vehicles with fixed daily schedules, we used a different modeling approach. Such vehicles include garbage trucks, delivery vans and trucks, and vehicles of care services. The key characteristic of this group of vehicles is that their activities vary rarely. Considering the aforementioned activity purposes, the vehicles with a fixed daily schedule usually have one main activity purpose, and in addition to that, the only other purpose is often the return-to-establishment-purpose. Furthermore, the vehicles follow a tour pattern, where the trip chain starts and ends at the same place, and the trip chain between the intermediate stops needs to be optimized.

Even though these vehicles all share some similarities, we further distinguished them into two groups. We differentiate between vehicles that meet demand with a small radius of action, such as garbage trucks and care service providers, and delivery service vehicles, making up just one part of the entire supply chain, and therefore serve a larger radius of action. For vehicles with a smaller supply chain, we used KiD to identify the number of trips of the respective business sector and distributed them randomly among the vehicles of a company. The destinations are distributed within the model area based on the business location and their vehicle fleet.

4. Methodology of modeling CEP delivery services

CEP-delivery differs from other business areas that mainly use vehicles on fixed schedules, like disposal business or care services. The demand for the latter services arises within the model area and is also met by vehicles that start and finish in the same area. This does not apply to delivery vehicles. While these vehicles meet the demand of delivering packages, that were, e.g. ordered in the model area, the packages themselves are usually not produced within the model area. Thus, their supply chain starts outside the model area.

In this chapter, the modeling approach with its macroscopic and microscopic parts is elaborated. The role of the macroscopic part is to assign the freight transit traffic, as well as the incoming and outgoing freight flows, to the road network. The incoming and outgoing freight flows – which also contain parcels – are fed into carefully selected connectors, which serve as feeding nodes for freight volumes by industries, as well as transshipment terminals for incoming and outgoing parcels. The incoming and outgoing parcels are further assigned to urban roads by the microscopic part.

In the microscopic approach, the determined parcels are distributed among the delivery service providers in the model area. For each vehicle of the delivery companies, a tour is determined, and the vehicles are finally assigned to the road network of the model area.

4.1. Macroscopic part of the model

In order to model long-distance transit freight flows, as well as incoming and outgoing freight flows – that also embrace transported parcels –, results of the ETISplus project are used. The ETISplus project has been funded under the European Union’s 7th Framework Programme and provides a reference database for transport modeling and transport policy analysis at the European scale and beyond (Newton et al. 2013; Szimba et al. 2013). Among others, ETISplus data contain Europe-wide and transport mode-specific demand data at the level of origin/destination (O/D) matrices. The underlying regional dataset includes all NUTS-3 regions and thus considers about 2.5 million O/D relations. For the work in this paper, the road freight O/D matrix is of relevance, which has been constructed by a three steps approach (Newton et al. 2013). First, domestic road freight O/D matrices at the NUTS-3 level provided by Eurostat were used for national O/D relations. Second, international flows were estimated under consideration of statistics on international transport (mainly available at a country/country level only), incoming and outgoing freight flows per NUTS-3 region, and travel impedances. Third, an iterative approach was conducted to align the whole road O/D matrix with national transport statistics on ton-kilometers. The O/D matrix refers to transport volumes (tons carried p.a.), differentiated by 52 commodities according to NST-2.

4.2. Microscopic part of the model

The macroscopic approach described above is used to yield the daily demand of packages of the model region. This demand is further used in the microscopic approach for the distribution of packages within the model area, which is divided into travel zones. For this, we first determined the number of distribution centers and the number of corresponding vehicles. The number of parcels determined in the macroscopic approach is allocated to the distribution centers in the model area. After this step, the parcels of each center are distributed within the model area based on the building density and the size of a travel zone. After the distribution of packages, the tour for each vehicle is created. As mentioned before, the tours of vehicles with a fixed daily schedule need to be optimized, as businesses want to be as cost efficient as possible. This optimization problem is a classic example of the vehicle routing problem. To solve this problem, all possible tours have to be calculated. This is infeasible due to the vast amount of possible tours. However, there are multiple heuristics to solve the vehicle routing problem have been presented (König 1995). To create routes for the vehicles we used a route-first-cluster-second approach. First, a giant tour is created, and in the next step, this tour is segmented into feasible parts.

After obtaining the freight demand of the industrial areas, the packages are distributed within the model area through the microscopic part of the model. For this, we first identified the main courier, express, and parcel services (CEP-services) and allocated them to the respective industrial area. This was done by first identifying the respective company through aerial photographs and attributes of OpenStreetMap data. OpenStreetMap provides several attributes of buildings and institutions, including the type of amenity, such as "post office" and the brand or provider of the respective location. This allows for a clear identification of the relevant company (OpenStreetMap contributors 2018).

In the second step, we estimated the vehicle fleet by the lot size of the distribution center, and the number of vehicles seen on aerial photographs. The results of this analysis of the model area are shown in Table 1. The packages within the industrial areas are distributed amongst the CEP-companies based on their nationwide revenue share, represented by the size of the vehicle fleet. The packages are distributed evenly within the model area for each carrier service, however, regarding the size of the model travel zone. Its size as well as the population and building density influence the number of packages in a model travel zone. A larger travel zone with a higher population and building density, therefore, attracts more packages than smaller and less populated travel zone.
After distributing the packages within the model area, a tour needs to be generated for each vehicle of each CEP-company. This tour is then segmented into individual tours for each vehicle, as shown in Figure 1.

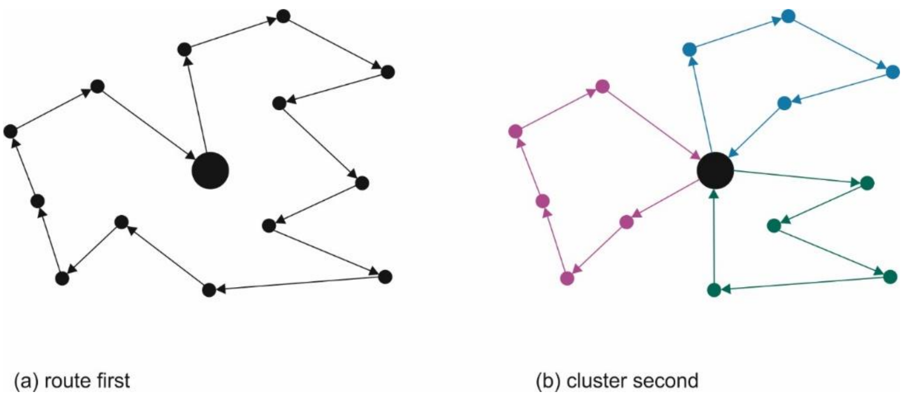

Figure 1: Schematic principle of a route-first-cluster-second algorithm

The individual tours are determined by adding nodes to a tour until an upper limit is reached. The flowchart of the determination of individual tours is presented in Figure 2. The giant tour is imported, and a new individual tour is initialized. Then the next node is removed from the giant tour and added to the current tour as the next stop. If the added node is the first stop of the current tour, the current time needed for the tour is the time it takes to get to the stop and the time at the stop. The number of stops at this point is evidently one. If the added node is not the first stop, the current time is the previously calculated current time, the time it takes to get from the stop back to the depot and the time at the stop. The number of stops is incremented by one. If the previously added node is not the first stop of the tour, the current time equals the previous current time and the time at the stop. The next step is to check whether the daily time limit or the stop limit is reached. This check is accomplished by comparing the current time plus the time from the last added stop back to the depot to a maximum time limit. For this paper, we set t_{max} to 8 hours, simulating a standard work day in Germany. The maximum number of possible stops s_{max} is determined by the mean load capacity of the vehicle.

If the current tour is shorter than the maximum time or includes fewer stops than the load capacity allows for, the process of adding a new node is repeated unless there are no more nodes in the giant tour. In this case, the depot is added as the last node of the tour, and the algorithm is terminated. If the limits for the tour are exceeded, the depot is also added as the last stop of this tour. The next step checks to see whether the giant tour is empty as well. If it is evaluated to be true, the algorithm is terminated. If there are further stops in the giant tour, a new tour is initialized, and the algorithm is run until the giant tour is empty.

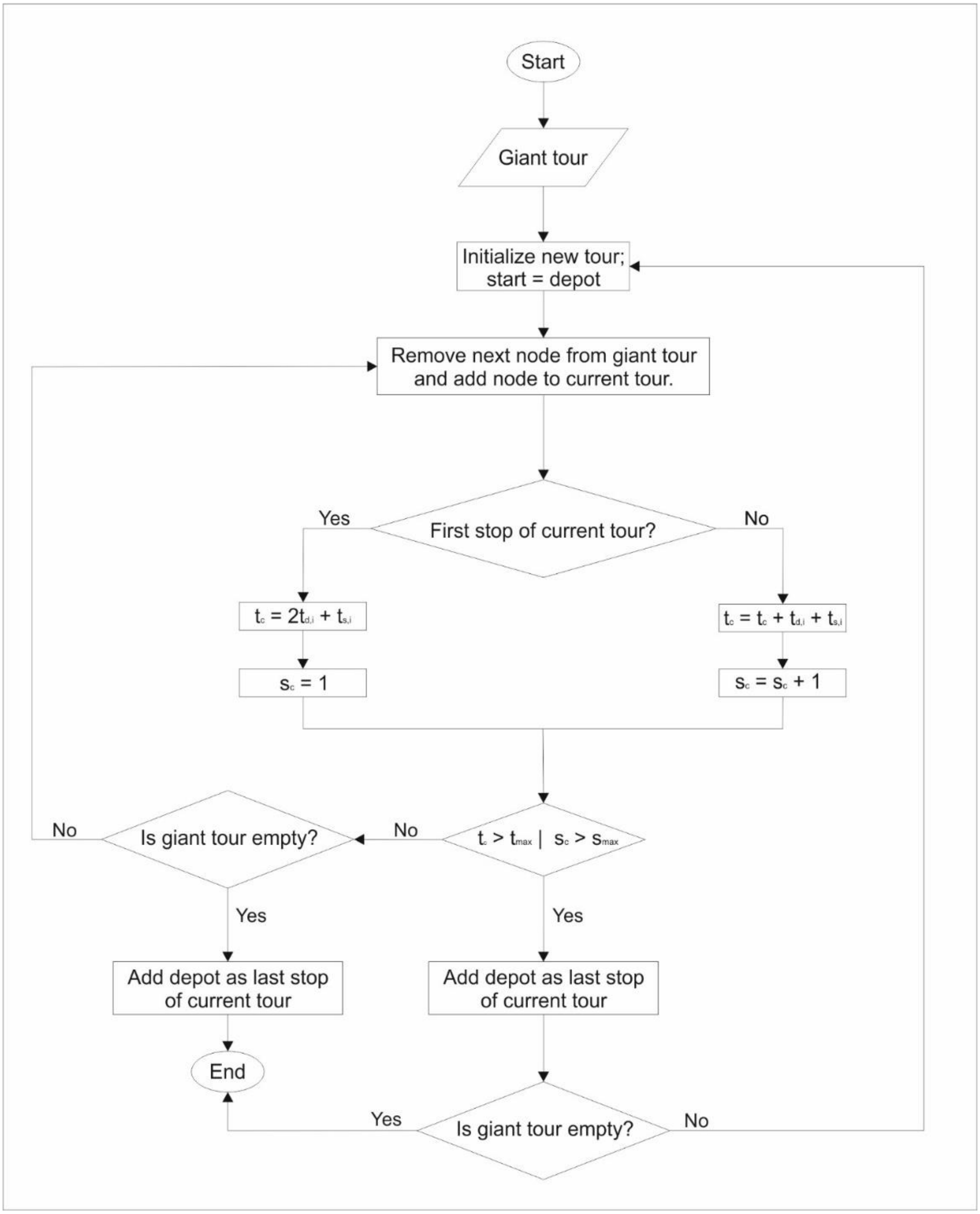

Figure 2: Flowchart of determination of individual tours

4.3. Integration of macroscopic and microscopic parts of the model

To obtain transit freight flows, as well as the incoming and outgoing freight flows at the network level, all road freight O/D relations of the ETISplus database were assigned to the updated ETISplus road network model (see Figure 3), under consideration of passenger traffic, applying road type-specific speed-flow functions.

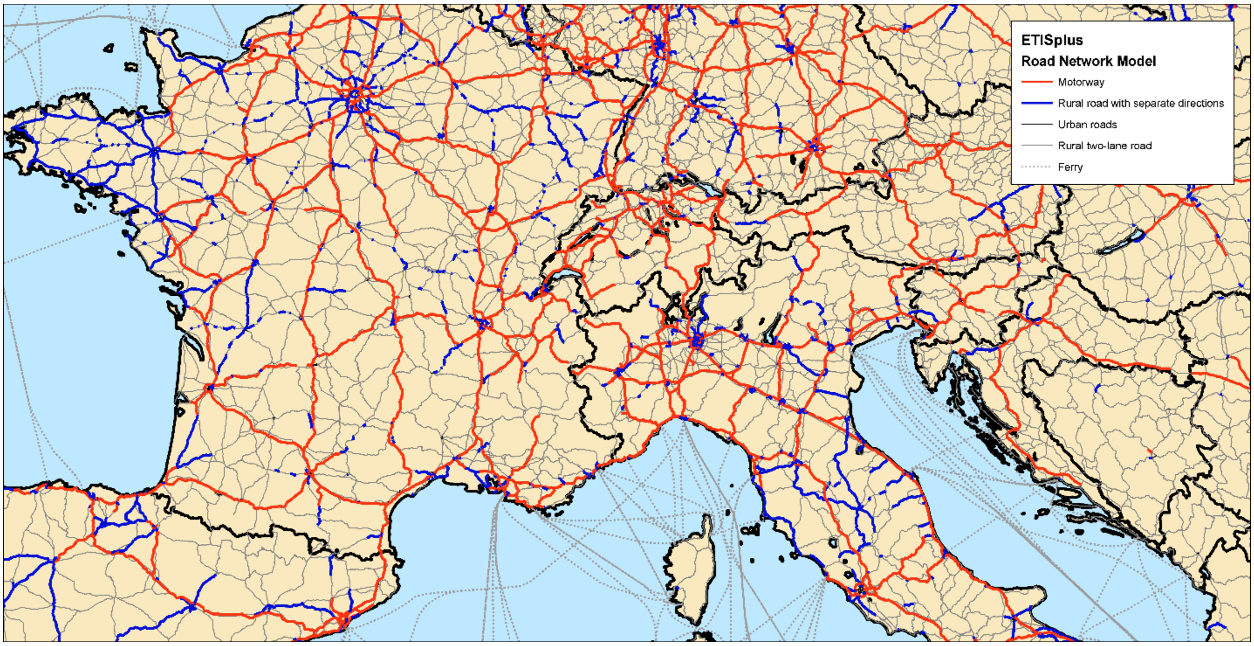

Figure 3: Road network model applied for route choice modeling

Since the zoning system underlying the ETISplus data (NUTS-3) is not sufficiently detailed for assigning freight transport at the regional scale, the following approach has been elaborated: first, CORINE land cover data (see Figure 4a) are used to elaborate industrial areas (Figure 4b), that represent origins and destinations of freight flows, as well as locations of parcel distribution centers. Subsequently, the identified industrial areas are grouped (Figure 4c). Finally, on the basis of these industrial areas and under consideration of the network topology, connectors are identified for each traffic zone, which serve as feeding nodes for originating and destining freight flows.

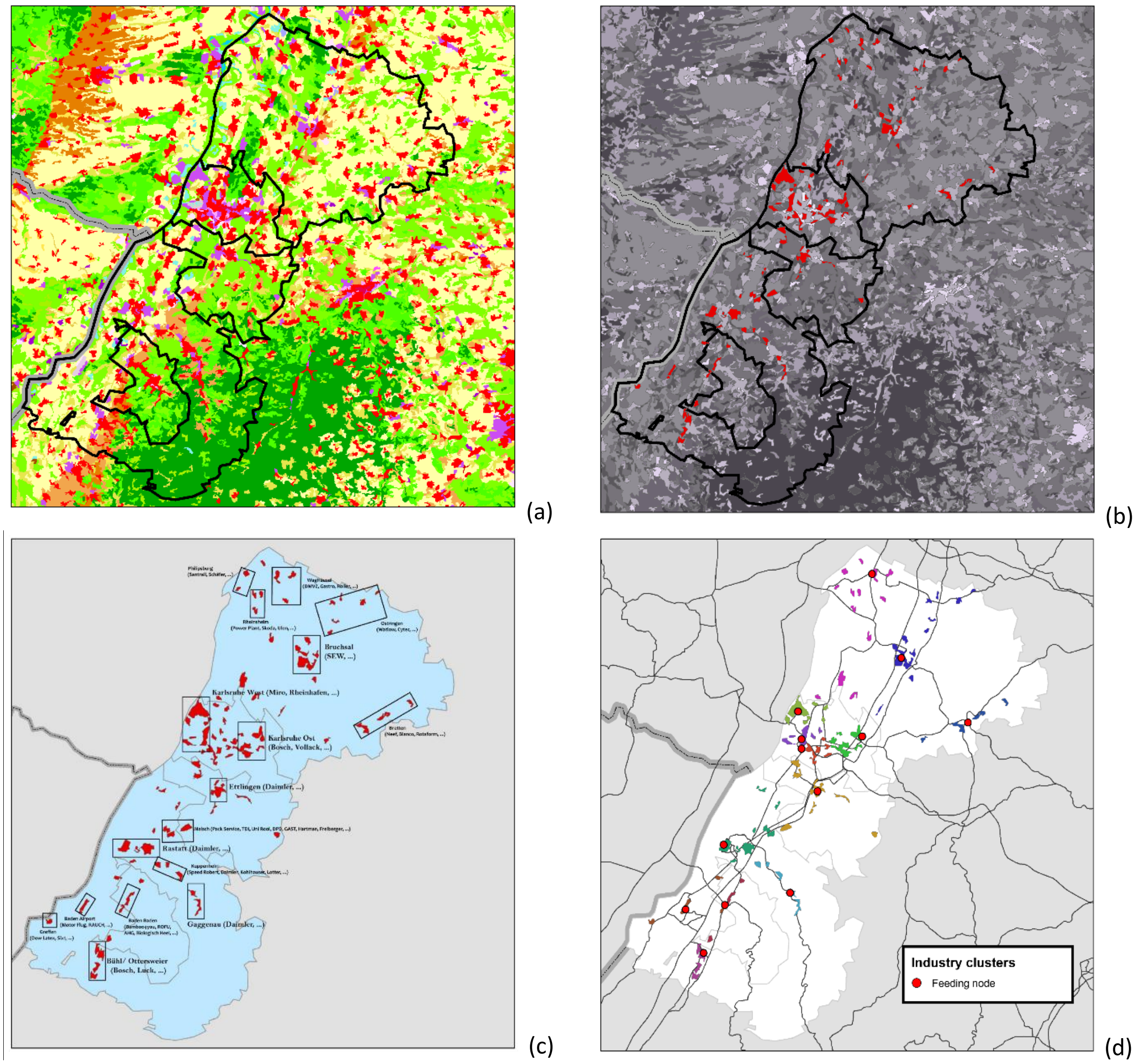

Figure 4: Approach to identify relevant connectors

In the following step, the weight and number of packages were derived for the model region Karlsruhe, a city with about 300,000 inhabitants, as shown in Figure 5 and Figure 6. The industry clusters introduced before within the model region are shown in Figure 5. As shown, four of these industry clusters are in Karlsruhe.

In order to derive the weight and the number of parcels with origin and destination in the NUTS-3 region "Karlsruhe Stadt", the following approach is applied. The transport of parcels by trucks is considered in the ETISplus matrix by the commodity group "miscellaneous". Thus, in a first step, the share of parcels in "miscellaneous" goods needs to be estimated. German freight road statistics available for NST 2007 (level 1) embrace the commodity group 15, "mail and parcels" (DESTATIS: Statistisches Bundesamt 2018). The NST 2007 categories 15-20 represent the goods, which are merged under "miscellaneous" in the ETIS database. In a second step, the share of parcels in the commodity group "mail and parcels" needs to be estimated. For this approximation, data by the United States Postal Service (United States Postal Service 2010) is applied, where the weight share of parcels in the commodity group "mail and parcels" amounts to 14.5%. This results in a weight share of parcels of 1.8% of the total weight of miscellaneous goods in the ETIS database.

Applying this share to the originating and destining freight flows of/to the NUTS-3 region "Karlsruhe Stadt" results in a total weight of parcels of 27,835 tons per year.
To approximate the number of parcels transported in Karlsruhe, the total weight is divided by an average weight of parcels. Literature and statistics show a rather disperse pattern of average parcel weights. While (Liang et al. 2016) calculated an average weight of 1.5 kg for a parcel transported by train in China, the (United States Postal Service 2016) reports an average of a weight of 0.78 kg for parcels transported by the US postal service. For the UK an average parcel weight of 13.6 kg is calculated using the total number of parcels (Ofcom 2017) and the total weight of parcels transported on UK roads (Department for Transport UK 2018). Using road freight statistics for Germany from DESTATIS (DESTATIS: Statistisches Bundesamt 2018) and BIEK (BIEK: Bundesverband Paket und Expresslogistik e.V. 2017), an average weight of around 2.5 kg per parcel can be derived for the year 2010.
Assuming an average parcel weight of 4 kg, 6.96 million parcels are sent and received in the city of Karlsruhe in 2010. Applying volume shares of the different segments of the German parcel market (BIEK: Bundesverband Paket und Expresslogistik e.V. 2017), 4.11 million business-to-consumer (B2C) parcels, 2.43 million business-to-business (B2B) parcels, and 0.42 million consumer-to-business/consumer (C2X) parcels are estimated.
Due to a lack of detailed freight demand data at the company level, the assumption is made that the destining/originating freight transport demand of each NUTS-3 region is distributed to the connectors according to the relative size of the industrial area the connectors are supposed to serve.
The microscopic part was subsequently applied to the model region of Karlsruhe. Figure 6 shows the assigned travel zones on which the tours are based. The travel times for each stop are calculated using the travel times between each travel zone. There are 468 Travel zones in total, which are generally smaller the closer they are to the city center.

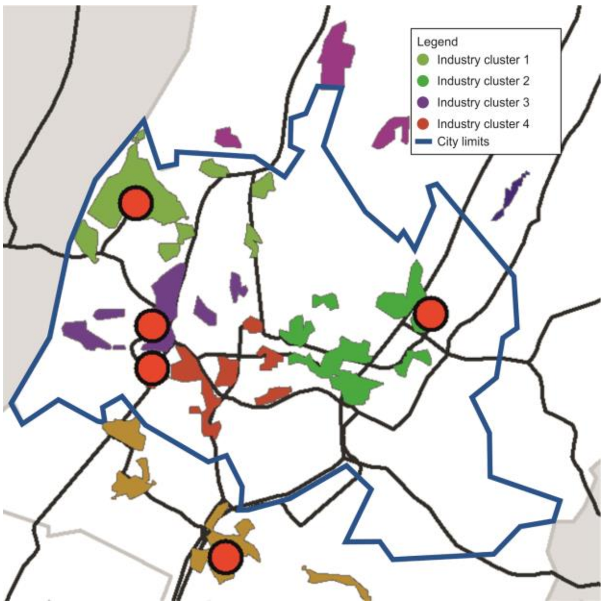

Figure 5: Industry clusters of model area

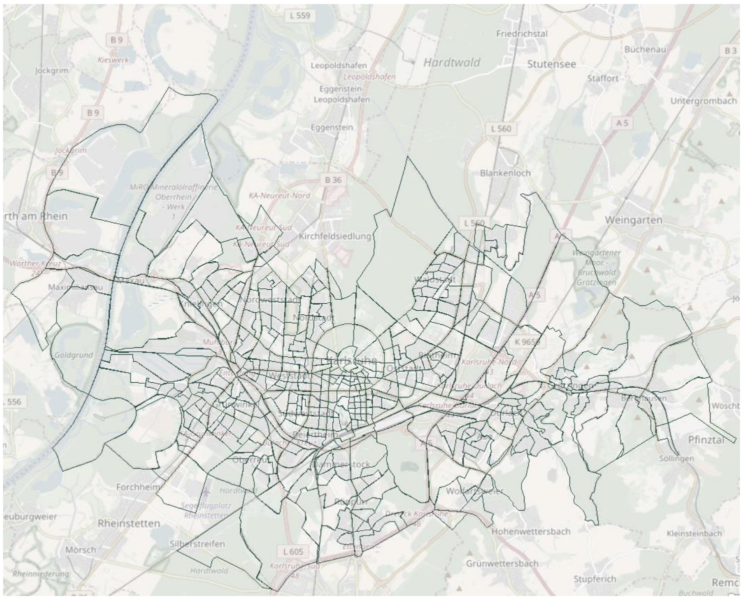

Figure 6: Travel zones of the model area

Within the model region, we first identified the main CEP service providers and their location within each industry cluster. The packages were first distributed based on their percentage shares of each industry cluster. In the next step, it was determined how much of the identified demand is met by each service provider. For the purpose of this paper, the authors have chosen two approaches of determining the breakdown by the service provider. The first approach is to distribute the packages based on the floor area of the respective buildings. The other approach we used is to take the revenue share of the respective service providers in Germany and distribute the amount of packages they deliver accordingly. An overview of the service providers in the model area, the floor size of their respective building, the types of vehicles they use and therefore what their respective mean load capacity is, the industry cluster each service provider is assigned to, and their revenue share are shown in Table 1. The differences between the floor areas of the respective buildings and the revenue shares are highlighted in Figure 7. In both approaches, DHL has the largest shares, however, using the floor area of their buildings yields a much smaller percentage share than using the actual revenue share (Statista 2017). This smaller percentage share can be explained by size buildings of GLS and DPD compared to their revenue share.

Table 1: Specs of CEP-services in the model area (Statista 2017; OpenStreetMap contributors 2018)

Company	**Floor Area [m^2]**	**Revenue Share [%]**	**Type of vehicle**	**Mean load capacity**	**Industry cluster**
DHL	8750	50	Trucks (3.5t)	160 packages	1 and 4
UPS	4418	13	Trucks (3.5t)	160 packages	2
Hermes	4000	11	Trucks (3.5t)	160 packages	2, 3, and 4
DPD	7114	14	Trucks (3.5t)	160 packages	4
GLS	5280	7	Sprinter (3.1t)	100 packages	3
Other	2500	6	Trucks (3.5t)	160 packages	2

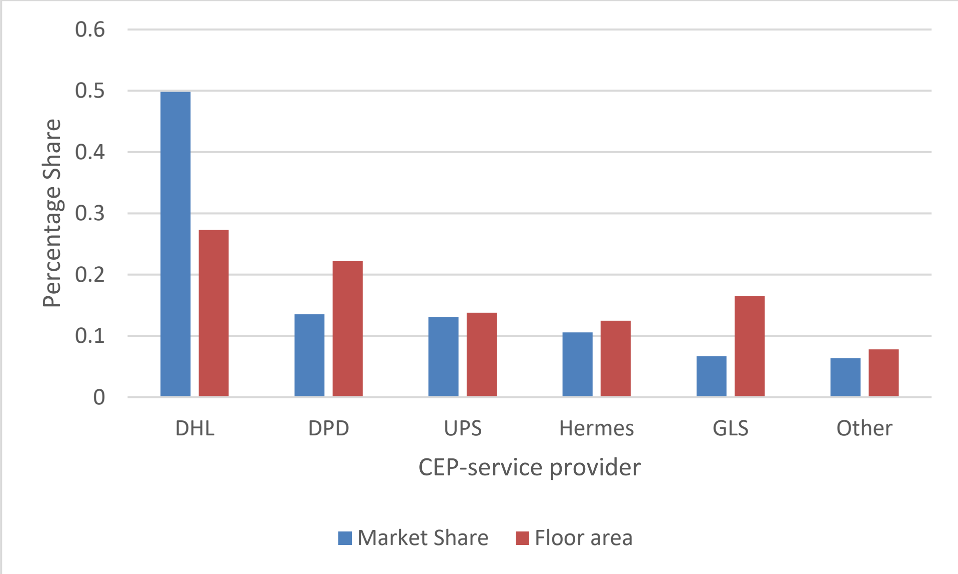

Figure 7: Comparison of CEP-service providers' percentage shares based on revenue share and floor area of buildings (Statista 2017; OpenStreetMap contributors 2018)

4.4. Results

The results of the macroscopic approach are assigned transit flows, as well as incoming and outgoing freight, flows in the wider scope of the use case (see Figure 8). The obtained assignment results are compared to traffic count data. For the road network model applied for the assignment – which is a long-distance network model without a detailed representation of local, regional or urban links – the modeled link loads are in the range of 10-30% below the traffic count values. This is in line with expectations since the flows modeled by the macroscopic approach do not cover any intra-zonal freight transport.

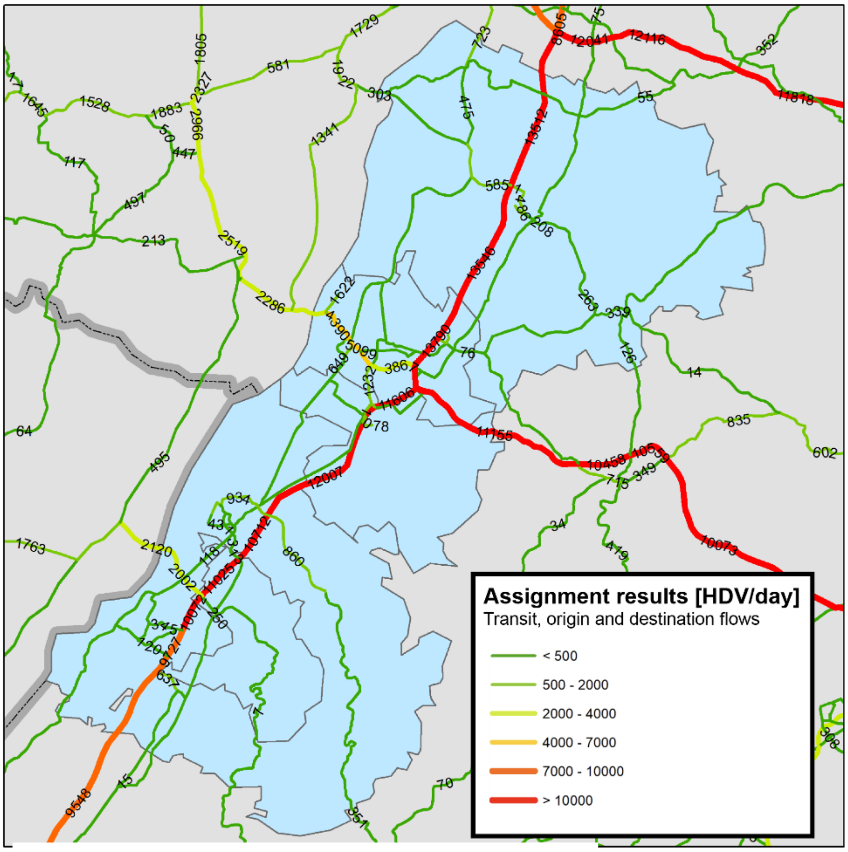

Figure 8: Assigned transit, incoming and outgoing freight flows

After obtaining the trips for each CEP-company in the model region, we assigned the values of the O/D-matrices to the network. We used two O/D-matrices, on where the percentage share of the company was based on the floor area of their building(s), and one where the percentage share was based on the revenue share. In order to assess the results of the model, we carried out a traffic count survey collecting data on delivery vehicles at a significant road crossing in the model area. The intersection is formed by two roads, one of which is a federal road. The roads are made up of four to five traffic lanes, indicating high traffic loads. The traffic count survey was carried out on a typical weekday, between 7 a.m. and 8 p.m. The results of the assignment and the traffic count survey are shown in Figure 9. The values represent the number of vehicles on a typical weekday. For many relations, both assignments show similar values to those of the traffic count survey. However, there are some relations where there are large differences between the modeled and surveyed values. Even though the assignment using revenue share values shows the largest difference between the survey values on one relation, overall the model values using revenue share information yields better results than using the company's floor sizes. Therefore, using revenue shares to distribute packages within a delivery zone has proven to be the better approach.

Since traffic count data and the model data are generally similar and only show few outliers, the tour generation model is an overall suitable approach. However, the distribution of packages among the travel zones needs to be calibrated to fit the values to the traffic count data.

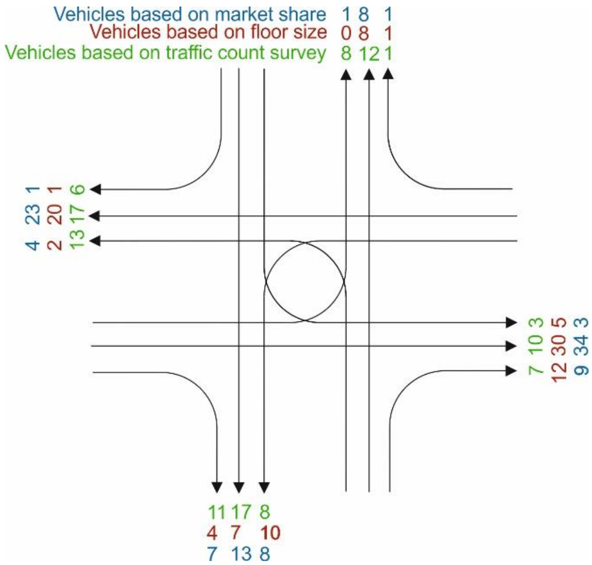

Figure 9: Results of network assignment and traffic count survey

5. Conclusion

In our paper, we presented several approaches to model commercial transport demand in an urban area. In order to do so, we distinguished different types of vehicles that are commercially active in urban areas. For vehicles with variable daily schedules, we used a nested logit approach to model commercial and private activity choice. For vehicles with fixed daily schedules and a small supply chain, we used a static method of estimating the number of trips and the tour patterns based on data of a national car-based survey. The focus of the paper was put on vehicles with fixed daily schedules and a long supply chain, i.e., vehicles of CEP-services. For those vehicles, we first chose to estimate the number of packages on a macroscopic level for Europe and subsequently distribute the estimated packages within a designated urban model area. The final distribution of packages and tours within the model area is done on a microscopic level, as every delivery vehicle is modeled individually.

The results show that the approach of dividing the model into macroscopic and microscopic parts is possible and yields promising results. Even though the modeled traffic loads of the macroscopic model are lower than the traffic count data, the model still yields good results, as the model does not account for intra-zonal freight traffic. Comparing traffic count data and model data shows that the microscopic model values and survey values are within the same range, even though some relations present different traffic volumes. This is mainly due to a flawed distribution of packages among the travel zones. After improving this part of the model, an extensive traffic count survey should be conducted, to calibrate and validate the model.

The model shows potential for future application as the sensitivity for control measures is given not only on a regional level but on a European level as well. Therefore, if impacts of measures on the trans-regional road network will show the effect on deliveries on an urban level, the model we presented is able to detect those effects and how they will present on the urban delivery system. Furthermore, the effects of different revenue shares among delivery service providers can be analyzed using the combination of macroscopic and microscopic approaches to model urban commercial transport demand.

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