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DEVELOPMENT OF AN INNOVATIVE MODEL CONCEPT TO IMPROVE THE AUSTRIAN TRANSPORT STATISTICS

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Several data sources are available to determine freight transport volumes and associated transport activities in Austria. These comprise the official statistics of freight transport provided by the statistical offices of Austria (Statistik Austria) and the European Union (Eurostat), complemented by national surveys such as the Cross Alpine Freight Transport Survey (CAFT), data of the toll collection system on highways and road counting stations on provincial roads. Due to different survey methods, the available data are not suitable for an integrated analysis without further transformation and interpretation. Therefore, the Austrian Ministry of Transport commissioned a consortium led by the Institute for Transport Studies of the University of Natural Resources and Life Sciences in Vienna (BOKU) to develop a model concept for an automated routine to calculate valid road freight transport statistics based on the integration of available data sources. Other modes of transport (rail and inland waterways) are only taken into account as far as they generate freight volumes on the road due to intermodal transport.

Keywords: Austrian transport statistics, transport modelling

1. Introduction

Important planning decisions require a valid, coherent, and consistent data base of freight transport in Austria and on a European level. These decisions concern infrastructure projects as well as legal and fiscal policies with a substantial impact on the national economy. The statement of the Council Regulation (EC) No 1172/98 of 25 May 1998 on statistical returns in respect of the carriage of goods by road specifies that to carry out its tasks the Commission *must have at its disposal comparable, reliable, synchronised, regular and comprehensive statistical data on the scale and development of the carriage of goods by road by means of vehicles … it is necessary to compile comprehensive regional statistics with regard to both the carriage of goods and vehicle journeys.*[1].

The official transport statistics which were adapted to meet EU requirements are mainly based on the surveys conducted by StatistikAustria (the Austrian Statistical Office) and the statistical offices at a European level. In addition to the official surveys of the public statistical offices there are a number of further sources which can be used to collect relevant data and describe the freight transport in Austria. These data are not directly comparable because most of the survey methods differ and various spatial, temporal, and functional aggregation units are covered.

Therefore, the Federal Ministry for Transport, Innovation and Technology commissioned a consortium led by the Institute for Transport Studies at the University of Natural Resources and Life Science in Vienna to develop a model concept to generate an automated routine for the calculation of valid freight transport statistics based on the integration of available data sources. However, of central interest is the road freight transport on Austrian roads.

2. Sources Used to Collect Data about the Freight Transport in Austria

2.1. Official RoadFreight Transport Statistics for Austria (StatistikAustria)

The data provided by the official freight transport statistics for Austria are collected by StatistikAustria. A sample survey based on the nationality principle is used, i.e. only Austrian companies are included in the survey without taking into account where their vehicles are on the road. Sampling is done by strata, by state, and size class of the notional payload of the transport company or place of work. To minimise the effort of the person filling in the forms no more than one vehicle per transport company is considered for the survey. The data are collected in writing with the help of a questionnaire which has to

be completed for the survey period of one week. The information collected includes among others: origins and destinations of the vehicle, number of axles on the vehicle and the maximum permissible weight as well as the types of goods according to the NST 2007 classification. This classification is subdivided at two levels: there are 20 divisions (e.g. food products, beverages and tobacco) and 81 groups which are subsections of the divisions (e.g. meat, fish, dairy products and ice cream). According to StatistikAustria lorries are defined as vehicles with a payload of more than 2 metric tons. The spatial recording is based on the 99 political districts in Austria and in foreign countries on level 3 of the Nomenclature of Territorial Units for Statistics (NUTS). In total, trips of roughly 26,000 vehicles are recorded per year [2].

2.2. European Freight Transport Statistics (Eurostat)

Trips by foreign lorries are recorded by the responsible institutions in the various countries and passed on to the Statistical Office of the European Commission (Eurostat). Data from the 27 member states of the EU and from Switzerland, Lichtenstein, Norway, and Croatia are compiled. The spatial recording is based on level 3 of the NUTS. Given the national responsibility, survey methods differ. The metrics used for freight transport are tonnage and transport performance, but there is no differentiation according to types of goods or types of vehicles [3].

2.3. Cross-Alpine and Cross-border Freight Transport (CAFT)

On behalf of the Federal Ministry for Transport, Innovation and Technology data about the cross-alpine and cross-border freight transport in Austria are collected every 5 years. The last such collection took place in 2009 and was a sample survey (at 9 Alpine crossings and 9 border crossings drivers were asked on the road). Trips of vehicles of a total weight of more than 3.5 metric tons were recorded, independent of the origin of the vehicles; the recording differentiated according to different axle configurations (lorry, lorry and trailer, articulated lorry). Drivers were asked about their origin and destination as well as the types of goods (according to NST 2007) they were transporting. The spatial recording was based on level 3 of the NUTS. In total, in 2009 about 22,000 vehicles were included in the survey at selected points [4], [5].

2.4. Data about Road Tolls on the Higher Class RoadNetwork

Freight carriers have to pay a toll for the permission to drive on motorways and express roads which depends on the kilometres driven and the number of axles of the vehicle. Every vehicle with a total weight above 3.5 metrical tons has to have a suitable transponder on board (Go-Box) [6]. When driving on a road section where the toll applies, this transponder sends its data to the corresponding receiver which is installed on a toll gantry and records the data of the vehicles passing underneath. The toll section is the section between two interchanges. There are a total of about 900 toll sections on Austria's motorways and express roads; there about 580 million data sets of individual vehicles are (automatically) recorded. The categories used for the recording are number of axles and the environmental class of the lorry.

2.5. Data from the Automatic Count Points

At the moment, there are about 360 permanent count points in Austria, of which 180 are installed at motorways and express roads; this means that the data from these count points overlap with the data collected via the road toll system. This "duplication" can be used to estimate the error rate of the automatic count points (assuming a virtually accurate recording of the lorries at the toll gantries). Since the devices at the count points differ from a technical point of view and since the governments of the various states are responsible for them, the recording of the freight transport is not done in a standardised way and does not use comparable categories [7].

2.6. Digital Network Model of the Austrian Transport Model

With the help of an economic model (Multi-Reg) a freight transport matrix was created for Austria and the reference year 2005. The spatial recording was based on the 99 political districts in Austria. On this basis, the calculated traffic flows were allocated to the 2628 traffic cells of the Austrian transport model according to the existing values for the modal split. To differentiate goods, 15 categories of goods according to NSTR24 were used (24 types of goods, e.g. grain, row oil). NSTR 24 was replaced by NST 2007 [8].

3. Problems of the Road Freight Transport Statistics in Austria

3.1. Data Accuracy of the Official Statistics

A comparison of the data sources for freight transport reveals a tendency to undercoverage of the road freight transport in the records of the official statistics (Statistik Austria and Eurostat) (see for example [9], [10], [11], [12], [13]). The crucial problem is the lack of accurate information about the overall transport volume and the performance of road freight transport; there are only some indications based on the comparison of the various data sources. It has to be mentioned that all these data sources are subject to random errors and biases due to the sample survey. **Error! Reference source not found.** provides examples for the differences encountered. Estimation with the help of CAFT results (Cross Alpine Freight Transport, [4], [5]) shows a total undercoverage of 13 %, and undercoverage of domestic transport of about 14 %.

Table 1. Road freight transport volume in Austria 2004 [MN metric tons]

	Domestic transport	Import / Export	Transit	Total
Official statistics	246.4	67.7	49.4	363.5
Estimation with compensation for undercoverage	288.2	74.2	53.4	415.8
Difference [%]	*- 41.80 (14.5%)*	*-6.5 (8.8%)*	*-4.0 (7.5%)*	*-52.3 (12.6%)*

Source: [11]

The following list provides some examples of possible reasons for the tendency of undercoverage found in official statistics:

- Currently road freight transport surveys are based on questionnaires which have to be filled in by hand for sample vehicles by transport companies which operate at least one lorry or a road tractor subject to registration. This task requires a considerable amount of time; many of the data required are stored by the companies in digital form [14]. Given the time-consuming recording it is reasonable to assume that companies try to save time by completing the questionnaires with a minimum of information which leads to an undercoverage of their trips. Since the companies are legally obliged to participate in the survey this means a strain on their resources. Therefore the questionnaires are frequently completed by people who are only insufficiently aware of the database available in the company.
- Empty miles have to be proved by copies of the respective tachograph discs but it is reasonable to assume that no company declares the excess loads of its lorries. Given the automatic inclusion of empty miles (one assumes empty miles from the end of a trip with cargo to the beginning of a new trip with cargo if the destination of the first and the origin of the second are not identical) the overall transport performance is underestimated and the share of empty miles in the total is overestimated.
- The statistics of the EU only cover the road freight transport of vehicles which are registered in the EU, Norway, Switzerland, Croatia, or Liechtenstein and are included in the surveys of these countries and provided that the EU receives the reports in time. Vehicles registered in third countries are not recorded.
- Trips which are part of the combined transport are included in the Austrian and EU statistics separately for the respective modes of transport; from an intermodal point of view they are therefore recorded several times. No illustrations of intermodal trip chains are available.

- Certain rules apply for the surveys conducted for the official statistics in EU member countries but the results differ because of different threshold levels (payload, total weight), sampling procedures and sample sizes, exceptions, survey methods, imputations, dealings with no answers, and grossing-up procedures.
- The currently used methods for the grossing-up of survey data of the official statistics do not use the currently available and highly accurate data of the freight transport on motorways and express roads provided by the toll gantries. These data contain more information than that of the individual count points, for example about routes and distances travelled on motorways and express roads. Moreover, the recordings include information about all lorries independent of the country of origin of the transport company.

3.2. Problems with Content-related Inhomogeneity

The Austrian data and the road freight transport data made available by Eurostat are processed in different ways. While the relevant legislation (unilaterally) defines minimum standards for the surveys conducted to compile Europe-wide statistics (e.g. upper limits for the payloads to be reported, upper values for the sampling error, etc.), inhomogeneities are mainly the result of the differences in national surveys which are later made available as part of the European road freight transport statistics. A detailed overview of the specific aspects of national surveys can be found in [3].

The data gathered by the toll gantries in Austria are not broken down by categories of goods or loads; moreover, they categorise the lorries by number of axles and not by tonnage. Since the transport generated by rail transport operators for other modes of transport than rail is not recorded for the combined transport, no information about origins and destinations is available; only the information about loading and unloading of the cargo within the rail network is available. But the other statistics do not include information about the combined transport for different modes of transport which would allow any linking of individual trip chains [15].

3.3. Problems of Spatial Inhomogeneity

At a spatial level, the Austrian data and the data about foreign lorries made available by Eurostat are aggregated at the level of political districts and the level 3 of the NUTS respectively; this means that it is not possible to allocate the data about the domestic traffic in one district/region to the respective road network. The toll data permit a spatial allocation of the routes from toll gantry to toll gantry or interchange and the screen line counts of the lorry traffic are usually arranged in such a way that most count points are not located at the borders of any districts. This means that a direct and unambiguous comparison of the official freight transport statistics with the toll data and screen line data is not possible; any such comparisons are based on modelled estimates.

4. Model to Create a Valid Freight Transport Matrix for Austria

4.1. Model Structure

The model which was developed to create a valid freight transport matrix envisages the merging of the various data sources of freight transport which are mainly based on sample surveys (questionnaires) as well as comparison of these data with roadside monitoring. The following data are available:

(1) Survey data
- SGVS, StraßengüterverkehrsstatistikÖsterreichs (Austrian road freight transport statistics)
- ESGVS, EuropäischeStraßengüterverkehrsstatistik(European road freight transport statistics)
- CAFT, Cross-Alpine Freight Transport
- ESGVS, Eisenbahngüterverkehrsstatistik(railway freight transport statistics)

(2) Monitoring data
- Toll data from motorways and express roads
- Road traffic counts

The fitting of these two sets of data is achieved with the help of the Austrian transport model; plausibility checks of the results are planned with the help of external data (e.g. fuel consumption in Austria) (Figure 1).

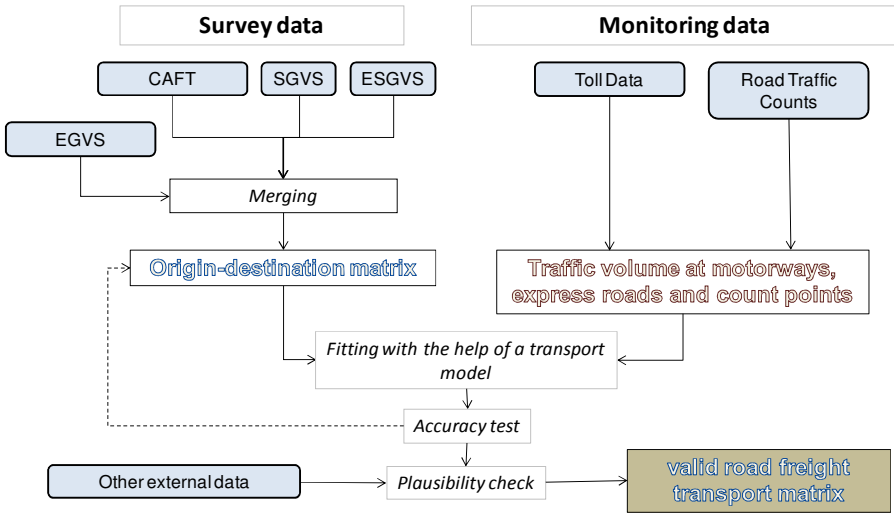

Figure 1. Methodological approach to create a valid freight transport matrix

4.2. Calculation Steps to Create a Valid Freight Transport Matrix

Estimation of matrix values missing in the data sets of Statistik Austria

Given the current data protection law, the freight transport matrix does not provide values for all origin-destination relations. Matrix values which are based on number of cases below a critical value are suppressed and are not visible for the user. Such values have to be estimated. An iterative estimation method is developed; in addition to the known matrix values it takes the number of trips between all origins and destinations at the level of political districts and the level 3 of the NUTS in foreign countries into account. To begin with, a matrix is used which was created as a part of the Austrian transport model with the help of the economic model Multi-Reg (see paragraph 2.6).

Disaggregation of the data provided by the European statistical office (Eurostat)

The level 3 of the NUTS is the aggregation unit for data provided by Eurostat. These data have to be disaggregated to achieve the required granularity, since a valid freight transport matrix on the basis of the political districts in Austria is the target. The disaggregation is based on the assumption that the transport connections of foreign companies are basically the same as those of Austrian companies if one considers comparatively small reference units. This assumption can be justified since the same structural and accessibility data can be considered as influential factors. The allocation of the aggregated transport connections, of the number of trips between all origins and destinations to the lower aggregation level follows the data provide by Statistik Austria for Austria.

Combination of the Austrian and the European road freight transport statistics

With the existing grossing-up factors two sets of data are combined and a plausibility check is conducted. The result is a raw matrix for the road freight transport at level (1).

Disaggregation of the raw matrix at level (1) to reach the level of the Austrian transport model

The target is a valid freight transport matrix at the level of the political districts in Austria and the basis for its creation is the Austrian transport model. The reason for this choice is the fact that information from the count points and the toll data is included in the transport model. The Austrian transport model is based on Austrian municipalities; in the case of conurbations a suitable aggregation is used (e.g. districts in the city of Vienna). In neighbouring foreign countries the aggregation unit is level 3 of the NUTS; the further away from Austria, the coarser the aggregation used. For the disaggregation the same method is used as for the data from European statistics, but instead of the distribution of the Austrian data base the distribution of the freight transport matrix of the transport model is used.

Combination of the CAFT data with the raw matrix at level (1)

The CAFT data are available as individual records. The information provided by the drivers questioned at the count points about their origin and destination was coded according to the aggregation units of the Austrian transport model. The result is a dataset which is compatible to the raw matrix at level (1). Since both the raw matrix at level (1) and the data for the cross-Alpine freight transport were determined by using samples, random errors and biases occur in both cases. Going by experience, the probability is

high that the variation for the individual origin-destination relations, which were collected as part of the survey, is quite big. In a first step the differences between all transport connections and the difference distribution are determined for the various types of transport connections for two comparable data sources (possible types of transport connections which have to be tested: differentiated by countries of origin, distance classes etc.). One assumes that the CAFT dataare more complete than those of the raw matrix; therefore CAFT data are used to replace or complement the values for transport connections derived from the matrix. Moreover, CAFT data are used for countries outside the EU. For the cross-Alpine transport, origin-destination relations between countries outside the EU are adopted. For other relation a flat rate revaluation is done and the mean of the revaluation effect from the previous step is used for these transport connections. The quality of the congruence of the origin-destination relations of the cross-Alpine road freight transport (CAFT) and Austrian and European road freight transport statistics is determined by using a statistical quality indicator, the root mean square deviation of the differences between origin-destination relations [16]. The result is a raw matrix at level (2).

Determination of the routes for the raw matrix at level (2) on the basis of the Austrian transport model

For the raw matrix at level (2), the routes for all transport connections are determined by using the Austrian transport model. For all transport connections and their routes, the links, count points, and interchanges on the motorways and express roads have to be identified and marked.

Creation of an interchange matrix based on the toll data

Whenever a lorry passes a toll gantry, the number of the on-board unit of the vehicle, the time of day and the number of axles of the vehicle are recorded. Thus it is possible to follow the routes of lorries on motorways and express roads and to create an interchange matrix of the freight transport.

Combination of the raw matrix at level (2) and the data from count points and toll data

For this step within the model, one can use the raw matrix at level (2) which is based on data from sampling surveys and the data from count points as well as toll data (in the form of an interchange matrix). Toll and count point data are far more precise because they are collected throughout the year. The section load deduced from the raw matrix (2) is compared with the results of the road traffic count. Incongruence in the load on working days and for the whole year is removed to create compatible framework conditions for this step in the modelling. With the help of the model algorithm the matrix at level (2) is then gradually adjusted to the pre-defined framework conditions, following the principle of minimum information gain or maximum entropy, as long as the deviations at the count points and for the interchange matrix do not exceed a pre-defined tolerance threshold (e.g. 1 to 5%) [17], [18]. This algorithm corresponds to the software tool"V-Strom-Fuzzy" of the transport simulation program VISUM of PTV AG; but there is the additional condition that the interchange matrix of motorways and express roads has to be taken into account. This is called "calibration of a matrix" or "simultaneous grossing-up procedure". This algorithm changes the origin-destination relation in such a way that, following the principles mentioned above, the pre-defined framework conditions are met as well as possible (see figure 2). This step is repeated several times until the matrix does not change any more. The result is an improved road freight transport matrix, compatible and aligned with all the available data of the framework conditions, which provides the respective information about transport volume and transport performance.

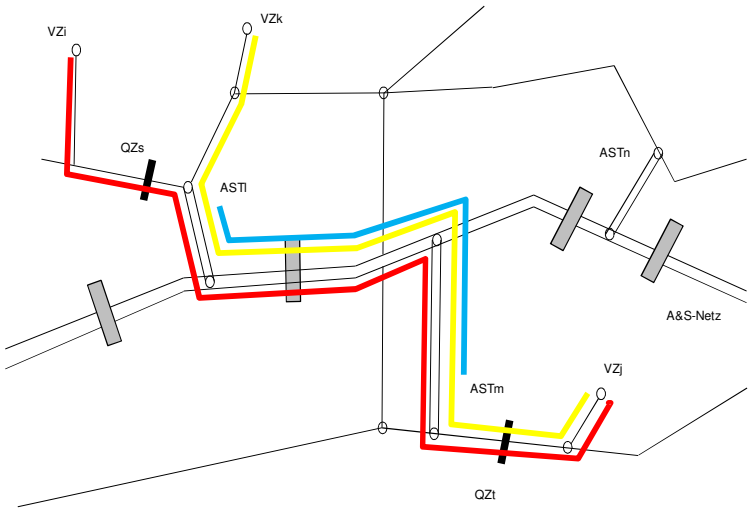

Figure 2. Graphics of the framework conditions for the modelling and fitting of toll data for lorries

Key:

AST_i Interchange with index i

VZ_i Transport cell or political district i

QZ_s Screen line count s

Toll gantry

Origin-destination relation of the raw matrix at level (2)

Origin-destination relation of the interchange matrix based on toll data

Framework conditions:

(1.) Σ (AST_l-AST_m) = Σ [of the origin-destination relations VZ_i – VZ_j passing AST_l – AST_m]
(2.) Count point Q_s= Σ[of the origin-destination relations VZ_i – VZ_j passingQ_s]
(3.) Trip distribution or distribution of the transport toll, with the types of transport connections and groups of goods as strata

Plausibility check with the help of other external data

While taking fuel tourism into account, the lorry matrix is applied to the road network by using the Austrian transport model; then the fuel consumption is estimated. The plausibility of the estimate is checked by comparing it with available data. Further plausibility checks are done on the basis of data from foreign trade statistics, since the flows of goods shown in these statistics can be interpreted as "aggregated" transport between various geographical units.

5. Future Plans

It is planned to use the procedure described here for Austria in autumn 2012. The objective is to provide a valid freight transport matrix. This includes the collection and processing of the data as well as a test of a prototype of the procedure. This will permit an evaluation whether or not the procedure is suitable for routine application in regular intervals. The quality of the results is to be evaluated on the basis of pre-defined target criteria.

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