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Using Toll Data to Improve the Quality of Road Freight Transport Statistics (RFTS) on Austrian Roads

Stefan Fleck
Statistics Austria

Sabine Schuster
Statistics Austria

Thomas Karner
Statistics Austria

Brigitte Weninger
Statistics Austria

Abstract

The European road freight transport statistics (RFTS) result from surveys, which are conducted by several states on the basis of EU-legislation. As there is no strict methodology for the implementation of these surveys, they are slightly different regarding the individual states.

This article analyses the additional use of toll data to improve the European RFTS and to impute transport volume and performance of third states affecting the Austrian territory. First, it was attempted to derive journeys as defined in the RFTS from the toll data and assign them to their type of transport. These analyses were very elaborate but showed no satisfying results. The number of journeys from the RFTS data and toll data were too different to allow a reliable interpretation. Hence, this approach was rejected.

A comparison of vehicle-kilometres on the higher road network between the two data sources proved to be more successful, as the differences were in an explainable and acceptable scope. Two thirds of them could be derived from methodological reasons regarding the survey in the respective member states and due to missing third states. On the basis of the vehicle-kilometres from the toll data a correction factor for the RFTS results of the individual member states and a procedure for the imputation of third states were developed and applied to publish weighted results.

Keywords: official statistics, European road freight transport statistics, type of transport, toll data, vehicle-kilometres.

1. Introduction

Centrally located in Europe, Austria faces a significant amount of transit transport on the north-south and east-west routes. For this reason road freight transport statistics (RFTS) are of special interest in Austria.

As mandated by (EC) No 70/2012 (Council of the European Union 2012), the member states of the European Union as well as Switzerland, Liechtenstein and Norway collect data on transport operations of road freight vehicles registered in their country and report them to the European Statistical Office (Eurostat), where they are merged into one database. These data are anonymised and redistributed in aggregated form to the National Statistical Institutions (NSIs) of each member state. Statistics Austria uses these tables to complement the national results and to publish the consolidated European RFTS on Austrian roads with some limitations. As the implementation of the surveys and statistical methods vary between the member states and no data is available for third states, Statistics Austria analysed the potential of other data sources to improve these statistics.

One of these data sources is data from the tolling system in Austria. Domestic and foreign trucks have to pay a driving distance based toll to use Austrian motorways and expressways. The *Autobahnen und Schnellstraßen-Finanzierungs-Aktiengesellschaft* (ASFINAG) records all movements of road freight vehicles on these road networks with automatic electronic measurement equipment (a so-called Go-box). Since 2016 ASFINAG provides Statistics Austria with a data set containing data on transport operations by all vehicles for which toll has been payed.

This article deals with the advantages and disadvantages of both data sets and describes how combining them can improve the quality of official statistics and provide data users with more accurate statistics on road freight transport in Austria.

2. Available data

2.1. Consolidated European road freight transport survey data sets (D-Tables)

With Commission Regulation (EU) No 202/2010 (European Commission 2010) it was decided that data transmitted by member states in accordance with Regulation (EU) No 70/2012 (Council of the European Union 2012) should be used to compile statistical tables, henceforth referred to as D-Tables (after Annex D of regulation (EU) No 202/2010). These tables are disseminated to the national statistical authorities of member states. In this context member state (MS) refers to the members of the European Union and the EFTA, with the exemption of Malta and Iceland. Some EU candidate countries (North Macedonia, Montenegro, Serbia) recently started to report RFTS data to Eurostat. As these data are not available for the whole period of 2015-2017, these countries are treated like the other third states in this study. Each member state has a certain degree of freedom how to implement its national survey, as long as it fulfils the precision requirements given in Commission Regulation (EC) No 642/2004 (European Commission 2004):

> *The percentage standard error (95% confidence) of the annual estimates for tonnes transported, tonne-kilometres performed and total kilometres travelled loaded for total goods road transport and for national goods road transport shall not be greater than* $\pm 5\%$.

The D-tables consist of eight data sets with aggregated data on journeys, vehicles-kilometres, transport volume and total transport performance of vehicles registered in the respective states. Provided annually by Eurostat, they enable national statistical institutes to produce statistics on road freight transport based on the territoriality principle. The D-tables contain a wide variety of variables, including data on the transported goods and their packaging, type of journey and detailed information on the vehicle (axle configuration or age class). A complete list of the variables can be found in regulation (EU) No 202/2010 (European Commission 2010). The data sets cover journeys by trucks with (at least) a minimum load capacity of 3.5 tonnes or maximum permissible weight of 6 tonnes in case of single motor vehicles. Some states choose to include smaller vehicles as the threshold quoted above. Special vehicles - such as agricultural vehicles, military vehicles and vehicles belonging to central or local public administrations - are excluded from the scope of the regulation. As the focus is on laden journeys, the reporting of empty journeys is optional and some states - such as Romania and Italy - choose not to provide data on empty journeys. A summary of each member states' methodology can be found in Eurostat (2018).

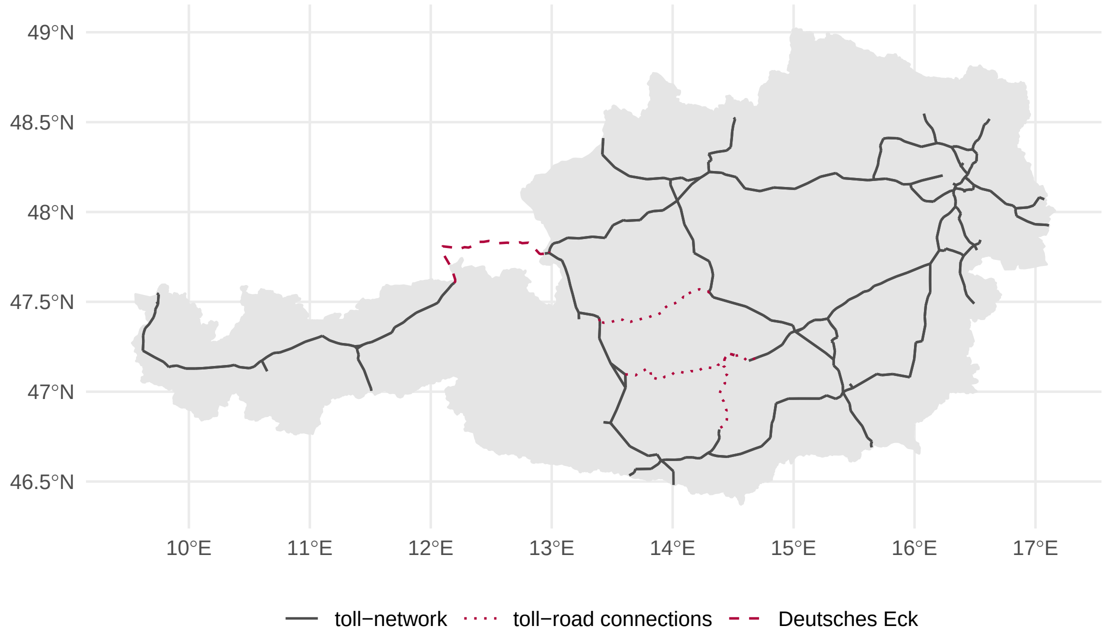

Figure 1: ASFINAG toll network and toll-road connections

In 2014, Statistics Austria developed a model to estimate the transport performance on Austrian territory from the D-Tables with the help of a distance matrix based on the origin and destination of the journeys (NUTS3 regions). The use of a distance matrix for road freight transport statistics in Austria is described in Karner, Weninger, Schuster, Fleck, and Kaminger (2017). A description of the methodology to estimate transport performance on Austrian territory can be found in Karner, Scharl, and Weninger (2014).

2.2. Data from the tolling system in Austria

Since 1997, a mileage-based toll applies for vehicles with more than 3.5 tonnes maximum permissible weight on Austrian motorways and expressways. This includes all lorries, buses and heavy camper vans. This right was obtained by ASFINAG with the *Usufruct Agreement concluded by virtue of the ASFINAG Authorisation Act 1997* (Republic of Austria 2019). Military vehicles, vehicles belonging to central or local public administrations are exempted from the toll. The criteria for exemption from tolling are very similar (but not identical) to the criteria for exemption from the Austrian road freight transport survey (Eurostat 2018).

The distance-related toll is collected using a fully electronic toll system. For this purpose, the toll road network is divided into toll road segments and for each individual segment the toll is collected separately by an authorised and permanently attached on-board unit (a GO-Box or a Split GO-Box). Such a network segment is defined from one highway exit to the next with usually no point in between where the vehicle could leave the highway. Every time a vehicle passes a toll collection point (a steel construction with antenna installed above the carriageway) the on-board unit in the vehicle communicates with the antenna and initiates the toll charging. A detailed description of the tolling system and its regulations can be found in (ASFINAG 2019). Since 2016, ASFINAG provides Statistics Austria with data sets containing data on all vehicles (except buses), for which toll is collected on Austrian motorways and expressways. In a cooperative effort between Statistics Austria and ASFINAG it was possible to impute traffic on some non-toll roads that connect toll-roads (henceforth referred to as toll-road connections) as well as traffic via the *Deutsches Eck*. This was achieved by incorporating data on travel times between the points of exit and re-entry into the toll network (see figure 1). The data set is anonymised and aggregated by start day of the vehicle movement.

Unfortunately, information on journeys according to the definition of the Consolidated European road freight transport survey is not available. The data set only contains data that is relevant for toll collection: vehicle-kilometres, the number of axes of the vehicle (including trailer), the Euro emission class and the country of registration of the vehicle. The vehicle-kilometre data collected by ASFINAG is directly used to calculate the tolls billed to the hauliers, hence ASFINAG spends great effort on ensuring its correctness.

Table 1 gives an overview of the content of the two available data sets.

3. Modelling journeys from toll data - an attempt

Type of journey and *number of journeys* are variables of interest that are included in most publications on RFTS produced by Statistics Austria. These important variables are not available directly from the ASFINAG data sets due to the manner in which the data is collected. This section outlines how it was attempted to model journeys from the ASFINAG data, with the goal to establish a direct link between ASFINAG and RFTS data.

In RFTS, a laden journey is defined as the movement of a road vehicle from the point of loading to the point of complete unloading of all goods. Any stops that do not result in the complete unloading of the vehicle (rest breaks, traffic jams, partial unloading of cargo) do not end a laden journey. Unladen journeys begin when a vehicle leaves a place completely empty and end as soon as it takes on cargo or returns to a depot at the end of a working day (Eurostat 2016). According to their place of origin and destination, journeys are classified into different types:

- Domestic: Place of loading and place of unloading are both in Austria.
- Receipt: Place of loading is abroad, place of unloading is in Austria.
- Dispatch: Place of loading is in Austria, place of unloading is abroad.
- Transit: Place of loading and place of unloading are both abroad and the journey transits Austrian territory.

Modelling journeys would not only provide an estimate for the total number of journeys but also make it possible to determining the type of each journey.

The ASFINAG toll data set contains vehicle counts per toll network segment, registered at a single cross section of each segment. This approach yields very accurate data on distance driven in the toll network, but makes modelling of journeys as defined above challenging. Several models for combining the per-segment vehicle counts to contiguous journeys were developed in collaboration between ASFINAG and Statistics Austria. The output of these models was then compared with the European road freight transport survey data.

To ensure that both data sets are directly comparable, it was necessary to first remove the journeys that did not take place on the Austrian higher ranking road network from the road freight survey data. To identify such journeys, a special postal code distance matrix which contains only the driving distances on the toll road network was developed based on the freely available Austrian GIP road network (Österreichisches Institut für Verkehrsdateninfrastruktur 2019).

The development of the final model was an iterative process subdivided into several steps considering average travel time, a differentiation between breaks and loading operations, driving bans and driving time regulations.

3.1. Average travel time

The original model proposed by ASFINAG for deriving journeys was based on the *average travel time* between two network segments. This average travel time is calculated for each

Table 1: Comparison of the available data sources

European RFTS data (D-Tables)	ASFINAG toll data
Survey method	
Sample survey with different methods used by the participating states	Total population survey (data collected is directly used to calculate the tolls billed to the hauliers)
Population	
Goods vehicles registered in the European Union (except Malta), Switzerland, Liechtenstein and Norway.	All vehicles (except buses) using motorways and expressways in Austria.
Vehicles with a maximum permissible weight greater than 6 tonnes or a minimum loading capacity of 3.5 tonnes. Some states voluntarily include smaller vehicles.	Vehicles with a maximum permissible weight greater than 3.5 tonnes.
Laden and empty journeys; transmission of data on empty journeys is optional.	Laden and empty journeys without a way to distinguish between them.
Units	
• Tonnes • Tonne-km • Vehicle-km • Number of Journeys • Number of vehicle records	• Vehicle-km
Variables	
• Country of registration • NUTS3 region of loading/origin • NUTS3 region of unloading/destination • Type of goods • Age class • Type of vehicle	• Country of registration • Axle configuration (2, 3, ≥ 4) • Euro emission class
Geographic units	
NUTS3 regions (median size ~1 924 km^2, varying widely)	Road network segment (median length ~3.5 km)
Temporal aggregation	
Yearly	By start day of the vehicle movement

segment on a daily basis from the travel times of all vehicles subject to tolling. If a vehicle took less than 1.5 times the average travel time + 180 seconds to appear on the next network segment after leaving the last segment, the model judges these movements to be part of the same journey. Otherwise, two journeys are registered. The travel time for toll-road connections - where the average travel time was not available - was specified as the 1.5 times the time required for the fastest route + 30 minutes tolerance. The first model developed by ASFINAG also split journeys at midnight, but this problem was solved early in the process of refining the model. After a careful comparison with European RFTS results it became clear that this threshold was much too low. According to this model, ASFINAG would have registered 75.8 million journeys on toll roads, as compared to 31.7 million according to the European RFTS. This overestimation affected Austrian and foreign vehicles equally.

3.2. Differentiation between breaks and loading operations

To improve the original model, it was attempted to account for rest breaks, traffic jams and other events that cause a vehicle to halt but that do not terminate a journey. For this purpose, several experiments with increased time-thresholds for combining transitioned segments into journeys were conducted. At first it was tried to incorporate data on rest stations and lorry parking areas (data provided by ASFINAG) and industrial sites (from CORINE land cover, see European Environment Agency (2018)) into the model, but upon closer inspection it became clear that this data was not very helpful as nearly all highway segments were close to such areas.

The first attempt added 30 minutes to the original threshold. The reasoning was that it is very unlikely that a lorry could leave the highway, conduct a whole loading operation and return to an adjacent road segment within that time span. This had a surprisingly small impact on the overall results and still amounted to 72.7 million journeys. None of the following attempts to gradually increase this threshold yielded satisfying results; even at 90 minutes the model still estimated 66.4 million journeys. At the same time, movements that were clearly separate journeys were erroneously merged by the model.

3.3. Driving bans and driving time regulations

Subsequently, the model was further improved by incorporating a rule-set based on Austrian driving bans and driving time regulations for goods transport vehicles. Driving bans refer to general driving restrictions for goods vehicles on Austrian roads:

- Night driving ban: In force each day from 10pm until 5am on all roads.
- Weekend driving ban: In force Saturday from 3pm until Sunday 10pm and on all public holidays from midnight to 10pm on all roads.
- Driving-ban calendar: Additional driving bans on certain roads based on the Austrian school holidays, published once per year.

In addition, several exemptions from driving bans exist; e.g. vehicles that transport live animals or certain perishable foodstuffs (fruits, vegetables, meat and meat products, etc..), garbage disposal or transport operations connected to inter-modal transport that are shorter than 65 kilometres. Please refer to the Austrian Road Traffic Act for a full list of exemptions (Republic of Austria 2018).

Besides these bans, driving time regulations impose the following restrictions on how long a driver may operate a goods vehicle:

- Maximum driving time per week: 56 hours per week and no more than 90 hours in two consecutive weeks.

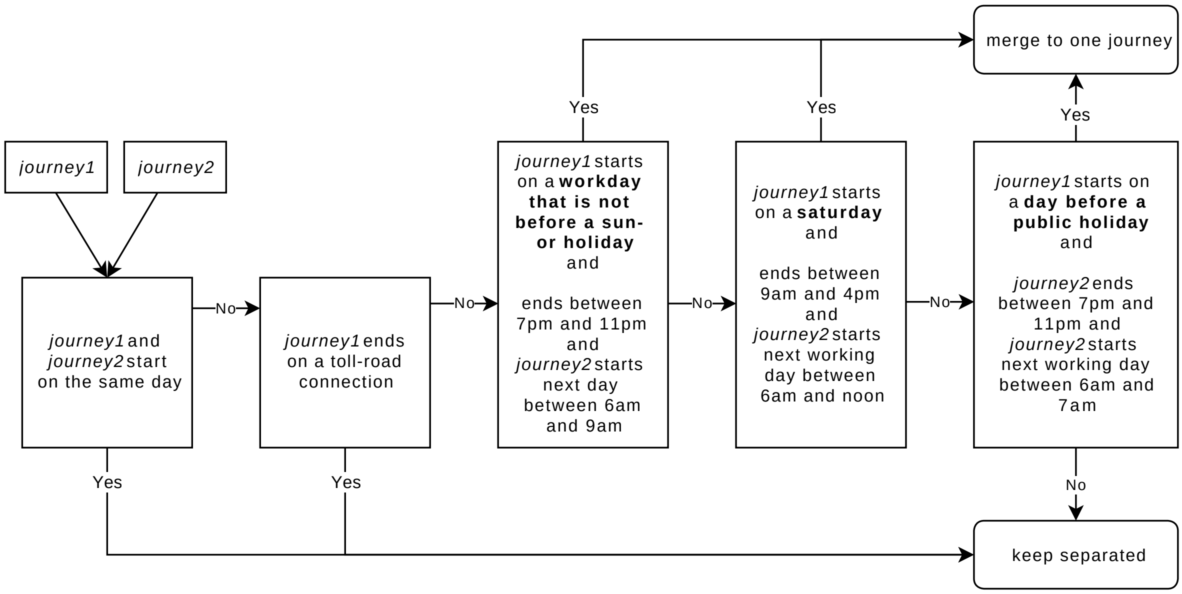

Figure 2: Simplified decision tree for merging two journeys (*journey1* and *journey2)*

- Driving breaks: After 4.5 hours drivers must take a break of at least 45 minutes. The breaks can be divided into two parts, one of at least 15 minutes and one of at least 30 minutes. Time when a person travels in a vehicle, but does not operate it, also count as driving breaks (i.e. if there are multiple drivers taking turns).

- Daily rest periods: At least 11 consecutive hours of rest in each 24-hour-period are mandatory, but three times a week this period can be shortened to 9 hours. Alternatively, it is permitted to have a 12 hour rest period, divided into two parts; one of at least 9 hours and one of at least 3 hours.

- Week rest periods: At least 45 consecutive hours, but a reduction to 24 hours is possible. Each missed hour of rest has to be taken at the latest 3 weeks later, connected to another rest period of at least 9 hours. These rest periods do not have to be taken on a weekend.

In summary, driving time regulations and driving bans are complex and contain many exemptions and special cases. For modelling journeys it was necessary to simplify this rule-set into criteria that could be modelled with the available data. This was achieved by combining driving bans and driving regulations into time-of-day thresholds. For example, the night driving ban is only in effect from 10pm to 5am, but the minimum legal rest period for the driver is 11 hours. The model assumes that every 11 hour break (+ tolerance time) that covers the time between 10pm and 5am was a night rest break. This rule-set was translated into an algorithm that was applied to the non-anonymised raw data by ASFINAG.

Figure 2 illustrates the simplified decision tree of the algorithm. This algorithm is used after a first pass of merging journeys based on 1.5 times the average travel time + 90 minutes tolerance period described above. It takes two journeys as input and decides whether or not both should be merged to a single journey. If both journeys are on the same day, they are kept separate because all possible breaks are already covered. If journey1 ends on a toll-road connection both journeys are also kept separate because the use of these connections is only allowed for loading or unloading purposes. In the next step, a combination of driving bans and driving time regulations was considered. Therefore, a tolerance time was added to the given bans e.g. night driving ban starts at 10pm each day, 11pm was set as treshold for the end time of journey1 to allow the driver to get to the next parking space. To receive the possible start time of journey2 on the following day, the driving time regulations (9 hours/11 hours for daily rest periods and 45 hours for week rest periods) were added to the end time of journey1.

- Workday not before a sun- or holiday: Journey1 starts on a regular workday (that is not before a Sunday or a holiday) and ends between 7pm and 11pm. If journey2 starts the next day between 6am and 9am the algorithm merges both journeys on the assumption that they are part of a single journey that was split by a night-rest period.
- Saturday: If journey1 starts on Saturday and ends the same day between 9am and 4pm it is merged with journey2 if journey2 starts on the next working day between 6am and noon. This rule covers weekend rest periods.
- Day before a public holiday: If journey1 ends on a day before a public holiday between 7pm and 11pm and journey2 starts the next working day between 6am and 7am, these journeys are also merged under the assumption that they were separated by a rest period.

In practice, the results did not fulfil the expectations and the model still resulted in 53.3 million journeys, while at the same time false merges were produced. For example, a journey was falsely merged resulting in the start and end of the journey in Vienna while passing Vorarlberg, a federal state which is about 600 km away from Vienna. Consequently, it was decided to abandon a further refinement of the algorithm and the idea of modelling journeys (and therefore transport types) directly from ASFINAG data as this data is structured in a way that makes it impossible to distinguish between loading operations and other events that may cause a vehicle to halt.

4. Analysing vehicle-kilometres from toll data

As a journey-based approach to the ASFINAG data proved not feasible, the next step was to analyse how vehicle-kilometres could simply be used to improve estimates for transport on Austrian roads. While the ASFINAG data sets contain vehicle-kilometres on Austrian toll roads, the D-Tables contain vehicle-kilometres between NUTS3 regions and no explicit information on which part of the journey took place on Austrian territory. To compare both data sets the distance matrix described in section 3 was used to estimate the vehicle-kilometres on the higher ranking Austrian road network for the journey data set from the D-Tables. The ASFINAG data on total vehicle-kilometres on Austrian roads were on average about 18% higher than the D-Table estimate. Figure 3 shows that the difference in vehicle-kilometres is negligible for Austria and only some foreign states vary widely between the two data sets. The deviation of the ASFINAG data to the D-Tables follows a country-specific pattern for all three years that have been evaluated (2015–2017). This implies that the differences are systematic regarding the reporting states.

5. Differences between ASFINAG and European RFTS data

5.1. Differences based on methodology

Different populations

As mentioned above, Eurostat only mandates quality guidelines for the implementation of the road freight transport survey and leaves the implementation details up to the member states. This includes the exact definition of the vehicle population. For example, Austria collects data on vehicles with a minimum load capacity of 2 tonnes that are not older than 30 years, while Italy collects data on vehicles above 3.5 tonnes load capacity that are not older than 11 years. In contrast the ASFINAG data set contains data on all vehicles from 3.5 tonnes maximum permissible weight, regardless of age or country of registration. Comparing this criterion to the Austrian Vehicle Register shows that a maximum permissible weight of 3.5 tonnes is roughly

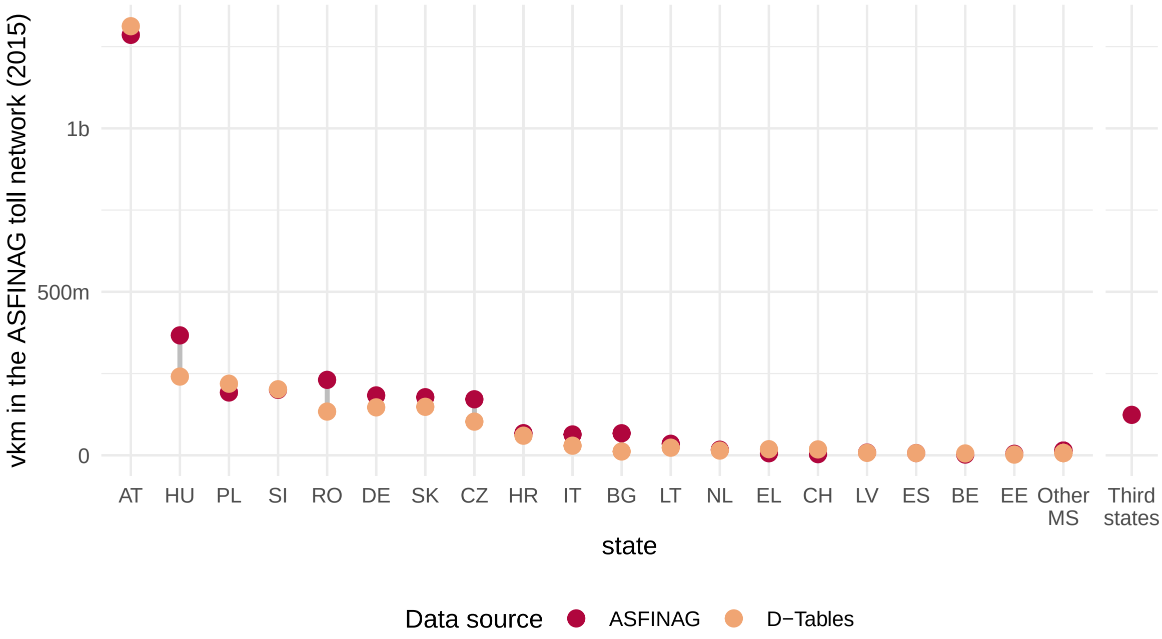

Figure 3: Vehicle kilometres on toll roads according to the European RFTS and ASFINAG data sets

equivalent to the Austrian threshold of 2 tonnes load capacity. This implies that calibrating the road freight transport survey results with the ASFINAG data would mitigate some of the methodological differences between member states. Analyses based on the Austrian Vehicle Register and Eurostat (2018) suggest that the varying population-definitions account for roughly 15% of the total difference between vehicle-kilometres derived from D-Tables and ASFINAG.

Missing empty journeys

Eurostat only mandates the collection of laden journeys, as the published results focus on transport volume and performance. While most member states choose to report empty journeys voluntarily, some that contribute significantly to the transport volume in Austria do not; especially Romania and Italy. Besides, experiences from the Austrian road freight transport survey have shown that empty journeys are often under-reported by the respondents. In the Austrian road freight transport survey, missing empty journeys are imputed: If the place of loading is different from the previous place of unloading an empty journey is added between these two places. There is little information available on how other member states deal with this issue. Consequently, the data on empty journeys has to be evaluated carefully and it is necessary to consider these issues when comparing ASFINAG data to the D-Tables. Missing empty journeys account for about 10% of the vehicle-kilometres difference between ASFINAG and D-Tables.

Missing transit journeys

For transit journeys, Eurostat only permits the declaration of a maximum of five transit countries. In case a journey transits more than five countries, only the first two and the last three countries are to be reported (Eurostat 2016). Due to its central position in Europe this is an issue with special relevance to Austria. For example, a journey from Turkey to the UK would not list Austria as transit country. In addition, under-reporting of transit countries cannot be ruled out either. If the transit countries variable is missing or incomplete, no reliable way exists to determine whether a journey was transiting Austria or not. Using a web service for traffic routing made available by the Geographic Information System of the

Commission (GISCO) it was possible to estimate if it was likely for a journey to mistakenly exclude Austria as a transit country. Using this estimate it was evaluated that roughly 20% of the difference in kilometres between ASFINAG and D-Tables can be explained by missing transit journeys. Using the ASFINAG data set to correct missing transit journeys is especially reasonable since transit journeys are conducted chiefly on the higher road network and the reliability of the ASFINAG data set is high for such journeys.

Driving distance calculation

The estimate for the vehicle-kilometres on Austrian territory for the D-Tables is based on the fastest route between NUTS3 regions. It appears logical that a driver would choose the fastest route; however, there are other factors that can influence the choice of route such as: tolls, gas prices, traffic conditions and legislation such as driving time regulations and driving bans. For such cases the current D-Table model would underestimate the driving distance by a factor that is hard to quantify from the available data. The ASFINAG data set contains reliable measurements of truly driven kilometres on the higher ranking road network that could be used to calibrate the kilometres driven.

Sampling Error

The D-Table data on foreign vehicles on Austrian roads is based on significantly less samples than the Austrian road freight transport survey. For example, in 2017 a total of 18 million tonnes-kilometres were projected based on survey data for 266 879 sampled journeys conducted by Austrian vehicles. In contrast, 23 million tonnes-kilometres were projected from the D-tables for only 27 088 sampled journeys. This means that the sampling errors for projected results for foreign vehicles are much higher than for Austrian vehicles. This is not surprising as the quality requirements set by Eurostat apply to the whole transport survey of each respective member state and only a small fraction of each state's fleet operates on Austrian territory. An exact estimate for the magnitude of this error would require access to the raw survey data of each member state, but it can be assumed that the magnitude of this error is about 3 to 4 times higher than for Austrian vehicles (square root of the difference in sample size expressed as a fraction).

5.2. Differences due to missing third states

While the European RFTS data only contain data on member states, some third states - like Turkey, Serbia or Bosnia and Herzegovina - also contribute significantly to the total transport volume on Austrian roads. According to the ASFINAG data for 2015–2017, an average of 130 million vehicle-kilometres are produced by third states each year (see figure 3 for a broader context), which explains about 18% of the difference between vehicle-kilometres according to D-Tables and ASFINAG. Imputing third states from the ASFINAG data enables Statistics Austria to provide more complete statistics on transport volume and performance on Austrian roads.

5.3. Summary

The difference in vehicle-kilometres between the ASFINAG and European RFTS data sets amounted on average to 18.1% per year for the time period 2015 and 2017. About two thirds of this difference is explainable by different population definitions (2.7%), missing empty journeys (1.8%), missing transit journeys (3.6%) as well as missing journeys by third states (3.3%). The remaining third of this difference might derive from a higher sampling error (compared to national road freight transport data) and limitations in the calculation of driving distances.

6. Correcting transport volume and transport performance

To correct for the issues described above, a correction factor based on the ASFINAG data set was developed. As already mentioned, the main variables of interest for the consolidated European RFTS on the Austrian road network are transport performance and transport volume. While these cannot be estimated directly from the ASFINAG data sets, it is possible to calculate a correction factor for these variables from toll data under the following assumption:

> Journeys by foreign vehicles are predominantly long journeys with mostly one loading/unloading operation of which a significant part is conducted on the higher ranking road network. This implies that the vehicle-kilometres are directly proportional to the number of journeys, transport performance and transport volume.

The assumption was verified by analysing European RFTS data: About 91% of all vehicle-kilometres by foreign vehicles occur on the higher ranking road network. Analyses of the D-Tables and the Austrian road freight transport survey data further showed that journeys with several partial loading/unloading operations occur almost exclusively in domestic transport by Austrian vehicles, while foreign vehicles conduct mainly long transit, receipt and dispatch journeys with one place of loading and one place of unloading. Hence, partial loading/unloading operations are not required to be taken into account when correcting transport volume.

Under this assumption it is possible to calculate a correction factor for number of journeys, transport volume and transport performance. As the deviations between ASFINAG and European RFTS data are systematic by country, the correction factor is calculated by country.

Furthermore, it was decided to not calculate such a correction factor for Austrian road freight vehicles. In 2017, about 95.3% of all journeys by Austrian vehicles were domestic journeys with an average length of 50.1 kilometres. Such journeys are often transports of building materials to contruction sites or deliveries/collections. Only about 61% of the vehicles-kilometres produced by domestic journeys occur on the higher ranking road network. Consequently, the ASFINAG vehicle-kilometres are much less suitable as a calibration value for journeys by Austrian goods vehicles. Additionally, a much larger sample size is available for Austrian vehicles and the sampling errors are well below the limits required by Eurostat.

6.1. Imputation of empty journeys

Before computing the correction factor, empty journeys must be accounted for. As explained above, the D-Tables do not contain data on empty journeys for all countries, while in the ASFINAG data it is not possible to differentiate between laden and empty journeys. An estimator for the share of empty kilometres (kilometres covered by an unladen vehicle) is required to make ASFINAG data comparable with the D-Tables. After an analysis of the D-Tables and the Austrian road freight transport survey, the share of empty kilometres of receipt, dispatch and transit of all member states[1] was calculated for the years 2015–2017. The median of this share was chosen as a lower threshold for empty kilometres (11%). Domestic transport was not considered as the share of empty kilometres for this type of journey is much higher and foreign hauliers conduct very few domestic transport operations on Austrian territory because such operations are limited by European and national law (cabotage). This minimum threshold is applied to countries that do not report empty journeys or countries that are suspected of under-reporting. For future analyses this threshold will be calculated from the three most recent years available.

6.2. Calculation of a correction factor

The correction factor $F_{corr}(\text{MS})$ for each member state is calculated by dividing the vehicle-kilometres from ASFINAG $vkm_{\text{ASFINAG}}(\text{MS})$ by the vehicle-kilometres that have been cor-

[1] Romania and Italy were not considered as they do not report empty journeys to Eurostat.

Table 2: Correction factor by state (most important states)

	correction factor			average yearly million vkm	
state	2015	2016	2017	original	corrected
HU	1.49	1.59	1.64	241	390
PL	0.85	0.91	0.82	304	274
SI	0.99	1.09	1.05	239	249
CZ	1.66	1.90	2.20	104	219
DE	1.25	1.25	1.16	173	210
SK	1.20	1.15	1.07	185	201
HR	1.13	1.10	1.14	75	83
IT	1.94	2.28	2.41	34	71

rected for empty journeys from the D-Tables $vkm_{\text{D-Tables}}(\text{MS})$:

$$F_{corr}(\text{MS}) = \frac{vkm_{\text{ASFINAG}}(\text{MS})}{vkm_{\text{D-Tables}}(\text{MS})} \tag{1}$$

Table 2 shows the resulting correction factors for the most important states for road freight transport in Austria. These factors can be applied to transport volume and transport performance from the D-tables to produce corrected values. The factors are relatively stable over the years for most states and are usually greater than 1. Data on states where the projections were based on less than 10 observations has always been suppressed in the European RFTS publications as required by Commission Regulation (EC) No 6/2003 (European Commission 2003). In future publications of the ASFINAG-corrected results of the consolidated European road freight survey, states with only a few transport operations in Austria will be aggregated into groups so that a suppression of results is less necessary.

6.3. Imputation of transport volume and transport performance for third states

As already mentioned, the ASFINAG data set is a source for journeys conducted by vehicles registered in states that do not report to Eurostat. While the ASFINAG data provides information on vehicle-kilometres for these states, there is no information about the quantity or type of the goods transported. Therefore, another data source for traffic on Austrian roads is used, the Cross Alpine Freight Transport study (CAFT). This study is performed every five years, is limited to a few sampling points across Austria and contains information on the loading of trucks from third states. The study states that most trucks that conduct long distance transit journeys operate nearly fully loaded and provides an average load weight of trucks including laden and empty journeys.

Combining the average load weight of trucks from third states from CAFT ($\bar{t}_{\text{CAFT}}$) with the vehicle-kilometres from ASFINAG (vkm_{ASFINAG}) allows an estimation of tonne-kilometres for third states:

$$tkm = \bar{t}_{\text{CAFT}} \cdot vkm_{\text{ASFINAG}} \tag{2}$$

The number of journeys is calculated by dividing the vehicle-kilometres from ASFINAG ($\overline{vkm}_{\text{ASFINAG}}$) by the average distance of journeys ($\overline{vkm}_{\text{D-tables}}$) derived from European RFTS data (without Austria) of the last three years:

$$journeys = \frac{vkm_{\text{ASFINAG}}}{\overline{vkm}_{\text{D-tables}}} \tag{3}$$

By multiplying the number of journeys with the average load weight of trucks from third states from CAFT it was further possible to estimate the total tonnes transported:

$$t = journeys \cdot \bar{t}_{\mathrm{CAFT}} \tag{4}$$

For the imputation it was also necessary to distribute the vehicle-kilometres according to ASFINAG over the transport types. This was done proportionally to the number of journeys by transport type, which is available directly from the CAFT data set (see table 3). Due to the limited scope of the data set it was decided to aggregate all third states and to impute only vehicle-kilometres, tonnes and transport types for third states and no other variables such as vehicle type, origin/destination or age of the vehicle.

Table 3: Parameters for estimating transport volume and performance for third states

Transport type	Average journey length (European RFTS) in km	Average tonnes (CAFT)	Share of total journeys (CAFT) in %
Domestic	89.7	3.9	2.7
Receipt	131.8	14.4	7.8
Dispatch	132.5	13.7	9.2
Transit	259.7	13.8	80.2

7. Results

Table 4 shows that applying the correction factors combined with imputing third states produces a noticeable increase in transport performance of around 20% per year. One quarter of this increase is due to the imputation of third states for which no data was previously available. The rest can largely be explained due to the reasons given in section 5. Differences for transport volume are less pronounced with an average increase of nearly 10%. This is because a majority of the tonnes transported (loaded and unloaded) are produced through short distances in domestic transport by Austrian vehicles.

It was expected that by integrating the toll data as an additional data source with the data from the European road freight transport survey, it would be possible to produce statistics with a much lower margin of error. To verify this assumption, it was attempted to calculate the coefficient of variation for the old as well as for the new results. To provide a reasonable estimate for the magnitude of the error, the number of sampled vehicles active on Austrian territory during the reference year is required for each member state. Due to the current structure of the data supplied by Eurostat this information is not available to the NSIs.

Three attempts were made to estimate the number of vehicles instead:

1. Each journey is conducted by a separate vehicle. This variant vastly overestimates the number of vehicles and therefore underestimates the sampling error.
2. All journeys from vehicles with similar characteristics (vehicle type, vehicle age-class, transport type) are by the same vehicle. This variant underestimates the number of vehicles and therefore overestimates the sampling error.
3. Randomly split vehicles from attempt 2 into several variants to gain a more realistic total number of vehicles in between both extremes. Without any information about the real number of vehicles from other member states on Austrian territory this approach does not lead to robust results.

The results of all three attempts and variants varied so strongly that it was decided to not publish them. To produce a usable estimate for the sampling error, data on sampled vehicles

Table 4: Transport volume and transport performance — member states (MS), third states (TS) and total

		1000 tonnes			million tonnes-kilometres		
year	states	original	corrected	change %	original	corrected	change %
2015	MS	462 284	496 747	7.5	37 776	43 507	15.2
	TS		7 585	-		1 664	-
	Total		**504 333**	**9.1**		**45 172**	**19.6**
2016	MS	489 574	529 035	8.1	39 295	45 667	16.2
	TS		8 046	-		1 766	-
	Total		**537 081**	**9.7**		**47 433**	**20.7**
2017	MS	509 955	548 662	7.6	41 927	47 827	14.1
	TS		8 303	-		1 822	-
	Total		**556 965**	**9.2**		**49 649**	**18.4**

active on Austrian territory will have to be acquired from the member states. Ideally, additional information such as stratification schemes would also be available. Therefore, a written inquiry is planned.

8. Conclusion

This article examines how data from the Austrian highway tolling system can be utilized as an additional data source to improve the consolidated European RFTS on Austrian roads.

The number of laden journeys and their classification into transport types (domestic, receipt, dispatch and transit) are important variables in road freight statistics. Consequently, the first step in analysing the toll data was the attempt to derive journeys to create a basis for direct comparison between both data sources.

For this purpose it was attempeted to create a model that was based on the daily average travel time for road network segments, but also tried to distinguish between loading operations and other events that might cause a vehicle to stop for an extended period - such as rest breaks (e.g. compulsory driving breaks and weekend rest periods) and driving bans (night driving bans, weekend driving bans). After a lot of careful evaluation and refinement, the model was ultimately abandoned. It proved to be impossible to derive loading operations from the ASFINAG data as real activities of trucks are too complex and too many factors can influence breaks in journeys. In addition, no validation set of real journeys from ASFINAG data was available which further limited the possible modelling approaches.

A comparison of both data sets based on vehicle-kilometres – a variable readily available from both data sets – proved to be more successful. There were deviations between both data sets, but these are largely explainable due to the limitations of the European RFTS data. For the reference years 2015 to 2017 the ASFINAG records on average 18.1% more vehicle-kilometres per year than European RFTS. Nearly two thirds of this difference can be explained due to methodological reasons like deviating population definitions between member states, missing empty journeys and missing transit journeys. Moreover, the ASFINAG data set includes data on third states that are not part of the European road freight transport survey.

Statistics Austria developed a correction factor based on the vehicle-kilometres from the ASFINAG toll data set that can be used to correct European RFTS data. Therefore, it was necessary to develop methods for the imputation of missing empty journeys and third states.

The corrected results show an increase of about 20% in transport performance and around 10% in transport volume and provide data users with more accurate statistics on road freight transport on Austrian roads. Statistics Austria will publish these results for road freight transport by foreign vehicles on Austrian territory from October 2019 onwards through the usual publishing channels. The corrected results will be available from the reporting year 2015 onwards.

Even though the calibration of the road freight transport survey with the accurate and reliable ASFINAG data provides a quality improvement for road freight transport statistics, this method is not applicable for all states as not all of them have a similar tolling system.

During the course of this study several issues were identified that affect the consistency of European RFTS data. Based on this experience, Statistics Austria recommends the following actions:

- Methodologies: Eurostat could strive for unified quality guidelines for the implementation of the road freight transport survey and establish rules how the member states should collect and report their data (e.g. an exact definition of the vehicle population).
- Empty Journeys: The imputation of empty journeys for member states that choose to not report them to Eurostat or that are suspected of under-reporting is based on the median of all member states for the transport types receipt, dispatch and transit. Closer analysis of how each member state handles empty journeys in practice could provide additional insight into how this imputation should be performed. In addition, the obligation of reporting empty journeys for member states should be considered to complete data on road transport statistics in Europe. Eurostat could propose a method for imputing empty journeys to the member states if these are missing or under-reported.
- Transit countries: The limitation to report a maximum of five transit countries results in partially incomplete data for long journeys. This arbitrary limit should be lifted. Additionally, Eurostat could integrate checks for transit countries into its automated validation programs.
- Third states: For the imputation of transport volume and transport performance of third states the only possibilty is the combination of vehicle-kilometres from ASFINAG with loading weights from the CAFT study. Hence, only aggregated values for third states and not more variables than just transport volume, transport performance and transport type can be calculated. Currently, it is not clear how this information gap could be closed. Some improvements could be achieved by extending the European road freight survey to candidate countries.

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Affiliation:

Thomas Karner
Statistics Austria
Guglgasse 13
A-1100 Vienna, Austria
E-mail: thomas.karner@statistik.gv.at
URL: https://www.statistik.at

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