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Carbon intensity of tourism in Austria: Estimates and policy implications

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ABSTRACT

In relation to international obligations, under the Paris Climate Agreement and as a member state of the EU, Austria is expected to drastically cut carbon emissions over the coming years. In order to achieve this goal, measures to reduce emissions have to be taken in all sectors of the national economy. In this context it is interesting to note that to date it is widely unknown how much emissions are caused by the Austrian tourism sector, despite its great importance in the country's economy, making up for 6.4% of the gross domestic product. The main reason for this situation is that most products and services consumed by tourists are not exclusive to tourism alone. Transport emissions, for instance, are caused by tourists, but also by commuters, transport of goods, and other reasons. The present paper explores how the complete emissions of tourism in Austria might be calculated for a given year, or even integrated into a regular monitoring scheme. In addition, first estimates are made, based on currently available data, following a destination-based accounting which takes into consideration not only emissions caused within Austria but also those generated abroad by travel of international tourists visiting the country. The results demonstrate the crucial importance of tourism as a contributor to the nationwide carbon emissions, especially tourist transport by car and aircraft. In line with these findings, the paper indicates what measures should be taken to reduce the carbon footprint of the Austrian tourism sector.

Management implications

The present study reveals the need to include indicators in the national tourism statistics and visitor surveys, which would permit a more accurate calculation and monitoring of the sector's carbon intensity. A thorough study on the origins and travel patterns of Austria's international visitors would be helpful as well. Despite the limited availability of data, it is clear that transport is causing the bulk of tourism-related emissions. Therefore, the following measures are recommended:

- Enhance the attractiveness of public transport options for arriving at destinations.
- Create conditions, which allow visitors to move around within tourism towns and regions without a personal vehicle.
- Focus destination management strategies towards high value, rather than volume.
- Direct tourism marketing towards domestic tourism and nearby markets and on enlarging length-of-stay of visitors.
- Make travel by aircraft in its current form less attractive for tourists and support research on alternative drive technologies.

1. Introduction

As a ratifying party of the 2015 Paris Agreement, Austria is obliged to extensively cut greenhouse gas emissions over the next years and decades. In 2018, the country's federal government presented a new climate strategy with an objective of reducing emissions by 36% until 2030 in comparison to the baseline of the year 2005 (BMNT & BMVIT, 2018; European Commission, 2016). The program of the new federal government, which was inaugurated at the beginning of 2020 even contains the goal of reaching full carbon neutrality by 2040 (Die Neue Volkspartei & Grünen, 2020). In order to reach this ambitious goal, it is necessary that all sectors of the Austrian economy take part and reduce emissions in the most effective way possible. The first step for doing this is to know how much emissions are generated and where. In this context, it is interesting that – as it was stated in the tourism section of the 2014 Assessment Report of the Austrian Panel on Climate Change (Moshammer et al., 2014) and confirmed by the literature review carried out for the present paper – it is widely unknown how much emissions can be attributed to the Austrian tourism industry. This situation is highly unsatisfactory, given the great importance of tourism in the country's

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economy: according to the tourism satellite account estimate for 2018 the sector's direct effects (without business travel) made up 6.4% of the gross domestic product; counting also its indirect effects, the number rises to 8.4% (Statistics Austria, 2019); in some regions, especially in alpine valleys in the Western part of the country, tourism even is the main economic activity (Prettenthaler & Formayer, 2011).

The only larger-scale study to date, a diploma thesis at the FH Kapfenberg by Friesenbichler (2003), is based on data of 2001, almost two decades ago. It tried to quantify the emissions of Austria's alpine winter tourism, calculating a total of 3.9 Mt CO_2 generated in the winter months of the year. It separated emissions into three categories: accommodation and gastronomy (58% of the total emissions), transport (38%) and infrastructure for winter sport (4%). The percentage given for transport, calculated on the basis of survey data of the national tourism agency (Österreich Werbung), is surprisingly low in comparison to most international studies on emissions from tourism. For instance, another study on alpine winter sport, on the French resort Sain-Martin-de-Belleville put the share of transport in total emissions for the year 2006 at 74.0%, compared to just 18.7% for accommodation and gastronomy (Duprez & Burget, 2007). A global estimate by UNWTO-UNEP-WMO (2008), based on data of 2005, estimated the contribution of tourism to the global CO_2 emissions at 4.9%, with 75% of tourism's emissions made up by transport. In a more recent study on global emissions from tourism by Lenzen at al. (2018), based on data of 2013, the share of total global emissions was estimated at 8.1%, with 49.1% caused by transport. The latter study follows an input/output-approach, taking into account much more aspects that are generally not related to tourism, like the production of food and goods that are consumed by tourists. It also calculates not only CO_2, but also considers equivalent emissions for other greenhouse gases. In this case tourism's global contribution is lower than in the case of CO_2 emissions alone, amounting to 5.3% of all $CO2_e$ emissions. However, this does not include short-lived emissions from air transport.

As this first outline shows, there are two main difficulties in calculating emissions from tourism: Firstly, it is important to define the boundaries of the tourism system, i.e. which economic activities, services and products to include and which not, and what share tourism makes up, for instance, in the occupation of a specific form of transport services or for specific goods. Currently, no generally accepted guidelines to do this exist and approaches vary greatly (Chen et al., 2018; Gössling et al., 2013; Paramati et al., 2017; Sun et al., 2018). Secondly, there is no consensus yet on how to quantify emissions from air travel, and if radiative forcing caused by aircrafts should be included, which would considerably increase the contribution attributed to air travel (Lee et al., 2009; Scott et al., 2010). In general, independent from the way its emissions are calculated, in all studies cited above there is no doubt that air travel makes up a considerable amount of the total emissions caused by tourism. The importance of emissions from international travel causes a further difficulty for the calculation of national tourism emissions, as it raises the question if the emissions of international tourists should be counted in their home country or otherwise fully or partially in the country or countries they visit (Gössling et al., 2013).

The present study focusses on the Austrian tourism industry, that is, tourism which is taking place within Austria (Lenzen et al., 2018, call this approach 'destination-based accounting', in contrast to 'residence-based accounting'). It therefore excludes travel of Austrian tourists to other countries. It does, however, intend to show how much emissions are caused by international tourists visiting Austria, not only within the country but also in their travel abroad, leaving it open to further discussion if they should be included wholly or partially in the national emissions. Currently, no general guidelines for defining national tourism emissions exist The study does not follow the exact way of any particular previous national study in another country, but is rather oriented on the availability of relevant datasets, as proposed by Perch-Nielsen et al. (2010). The results are intended to give indications for federal, state and municipal governments as well as for tourism associations and individual businesses on how to reduce the greenhouse gases caused by tourism in Austria.

2. Materials and methods

In Austria, the Environment Agency Austria together with the Statistics Austria publishes yearly data on air emissions, including CO_2 and all other relevant greenhouse gases: methane (CH_4), nitrous oxide (N_2O), partially fluorinated and fully fluorinated hydrocarbons (HFC, FC), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3), by economic activity according to the ÖNACE classification (Environment Agency Austria & Statistik Austria; Environment Agency Austria, 2018). While HFC, FC, SF_6 and NF_3 are expressed in the data as carbon dioxide equivalents (CO_2e), CH_4 and N_2O are expressed in tonnes. In order to calculate their CO_2e values, the present paper followed the indications by the 5th assessment report of the International Panel on Climate Change (2014). The emission values applied for each economic activity were based on the UNFCCC (United Nations Framework Convention on Climate Change) method. The ÖNACE classification does not separate tourism from other economic sectors, but contains different activities, which can partially be attributed to tourism. In lack of specific environmental data, the present study therefore uses the economic data from the Austrian tourism satellite account, developed as well by the Statistics Austria. In the most recent documentation of the calculation of the tourism satellite account, for 2012 and 2013, the following estimates are made for tourism's share in the demand of different goods and services:

- Accommodation and gastronomy: 70%
- Personal transport services: 25%
- Travel agencies, tour operators and other reservation services: 100%
- Cultural services and services for sports and leisure: 32%
- State-specific tourism goods and services as well as tourism-related and non-tourism related goods and services and valuable objects: 1%

Applying this method, an estimate can be made regarding emissions caused by tourism in Austria. It does not, however, contain emissions generated abroad by international tourists visiting the country. In order to estimate this number, first of all it is necessary to know where tourists in Austria come from .[1] In this context, the tourism statistics of Statistics Austria (2018) offer data on tourist arrivals from all EU member countries as well as 19 other important countries of origin and several country groups. In the case of Germany and Austria, data of origin is available not only on the national but also on the federal state level. Based on these data it is possible to roughly estimate travel distances. However, transport emissions do not only depend on distance, but also on the means of transport. In this context, the study used the emission factors calculated by the Environment Agency Austria for the year 2016 (see Table 1). It should be noted that for aviation, this includes an approximation for non-CO_2 warming effects, expressed as CO_2e. In order to know how many tourists used which mode of transport, survey data from the visitor survey T-MONA carried out by Österreich Werbung were used (un-published data for the tourism year 2017/18, solicited directly from Österreich Werbung), using a weighted mean of the numbers for the summer and winter season, depending on the respective number of contestants (Fig. 1). In the case of transport emissions by car

[1] It is worth noting, in this context, that there is a study on transport emissions for tourists who visited the Austrian town Alpbach in the winter months of 2015, based on the municipality's visitor register, which allowed for a more specific definition of the tourists' provenance (Unger et al., 2016). The realization of a study of this type on the national level would not only present a great challenge due to the vast amount of data sources but also because many tourists visit several towns during their travel, therefore, in a national account they would be registered twice or several times.

Table 1
General emission factors for different types of transport in Austria (2016).

Transport type	CO_2e emissions in g per km per person		
	direct	indirect	total
Passenger car (average of Diesel and gasoline)	148.1	70.3	218.4
Coach	43.2	14.7	57.9
Service bus	37.9	14.2	52.1
Train	5.4	9.0	14.4
Aircraft (national)	770.8	63.8	834.6
Aircraft (international)	413.8	34.2	448.0

Source: Environment Agency Austria, 2018.

Table 2
Estimated tourism-related emissions according to economic activity in Austria (2016).

Sector	Mt CO_2	Mt CO_2e	share of Austrian emissions (including private households)		share of emissions of the Austrian economy	
			CO_2	CO_2e	CO_2	CO_2e
Accommodation and gastronomy	0.17	0.28	0.18%	0.27%	0.24%	0.35%
Personal transport services	3.93	3.97	4.32%	3.83%	5.70%	4.90%
Travel agencies, tour operators and other reservation services	0.02	0.02	0.02%	0.02%	0.03%	0.02%
Cultural, sport and leisure services	0.03	0.03	0.03%	0.03%	0.04%	0.04%
Other tourism-related and non-tourism related goods and services[a]	0.003	0.01	0.003%	0.01%	0.004%	0.01%
Total tourism	**4.15**	**4.31**	**4.55%**	**4.15%**	**6.01%**	**5.32%**

[a] Based on emission data for retail sale.
Source: calculation based on data from Environment Agency Austria & Statistics Austria (2018) and Statistics Austria (2014).

as it was assumed that car occupation on longer travel is considerably higher than in everyday use, especially for commuting; in the emission factors given in Table 1, the expected occupancy is just 1.15 persons per car while for this research we estimated car occupancy at 2.5, which lowers the emissions per km per person to 100.5 CO_2e. In European countries not included in the T-MONA survey it was assumed that the shares of different transport types were as high as in other countries at a similar distance.

In the case of visitors coming from outside Europe, it was assumed that 100% arrived by aircraft. This was also applied to the visitors from the U.S., despite the values given in the data from TMONA (only 45% responded that they had come to Austria by plane), as it can be assumed that they arrived in Europe by aircraft in the first place, though they might have entered Austria using another type of transport. Land distances were calculated from the geographic centre of the respective country or federal state to the city of Salzburg (which is located at a central position between the Eastern and the Western part of Austria), using Google Maps (www.google.com/maps), while flight distances were calculated from the respective capital cities to Austria's most important international airport, Vienna, using the web tool GreatCircleMapper (https://www.greatcirclemapper.net/). For travel of domestic tourists within Austria the distance of Vienna to Innsbruck was applied.

Source: calculations based on data from the T-MONA survey, solicited from Österreich Werbung.

3. Findings

As it was outlined in the methodology, due to the lack of more accurate data, the following findings have to be treated as rough estimates, based on a series of assumptions, which could not be further validated yet. Table 3 represents the findings regarding the first step of this research, using emission data from Environment Agency Austria & Statistics Austria (2018) and shares of certain sectors based on the documentation of the methodology of the Tourism Satellite Account of Statistics Austria (2014). It was estimated that the tourism sector made up 4.6% of the Austrian CO_2 emissions and 6.0% compared to the Austrian economy, excluding private households. In the case of CO_2e, tourism's share was lower, with 4.2% of the total emissions and 5.3% of the emissions attributed exclusively to the economy. The single most important economic activity causing the emissions generated by tourism is personal transport, which makes up 94.8% of the industry's CO_2 emissions and 92.2% of its CO_2e. Despite its importance from an economic point of view, as a generator of income and employment, the share of the classical tourism sector, accommodation and gastronomy, is very low. The share in total emissions, according to these estimates, is slightly lower than the share of tourism in the national economy, which

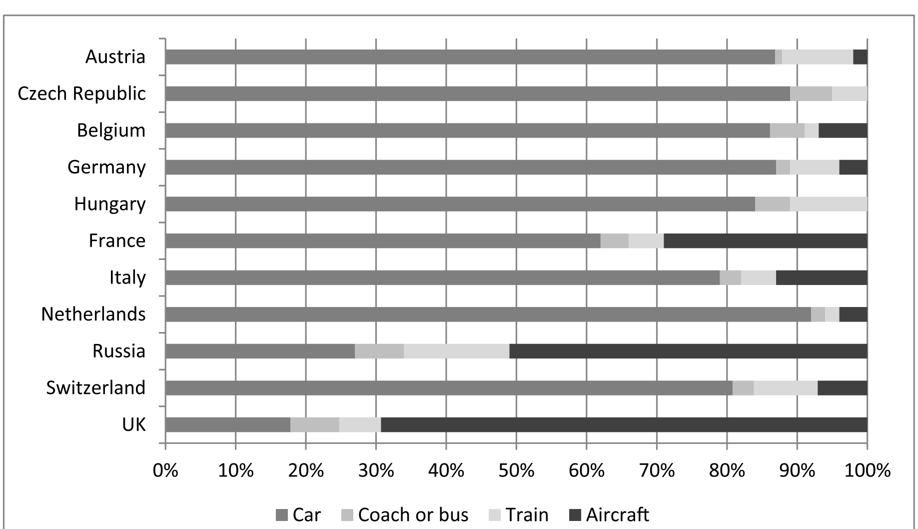

Fig. 1. Shares of different modes of transport among tourists in Austria from selected countries of origin (tourism year 2017/18).

Table 3
Number of tourists visiting Austria and transport CO_2e emissions by country and country groups of origin (tourism year 2018).

Country of origin	Tourist arrivals*		Emissions in CO_2e		
	Number	Share of total	Per tourist (in kg)	Sum (in Mt)	Share of total
Austria	14,004,877	31.5%	67	0.9	2.7%
Germany	13,965,774	31.4%	131	1.6	4.4%
Arab countries	391,669	0.9%	3355	1.3	3.8%
Australia and New Zealand	170,270	0.4%	14,510	2.5	7.1%
Belgium	579,594	1.3%	215	0.1	0.4%
China	968,894	2.2%	6693	6.5	18.5%
Denmark	364,092	0.8%	269	0.1	0.3%
France (incl. Monaco)	543,696	1.2%	418	0.2	0.7%
India	191,363	0.4%	4982	1.0	2.7%
Israel	184,274	0.4%	2025	0.4	1.1%
Italy	1,093,488	2.5%	248	0.3	0.8%
Japan	218,791	0.5%	8216	1.8	5.1%
Canada	117,917	0.3%	5923	0.7	2.0%
Netherlands	1,985,413	4,5%	206	0.4	1.2%
Poland	535,475	1.2%	194	0.1	0.3%
Russia	350,408	0.8%	929	0.3	0.9%
Switzerland (incl. Liechtenstein)	1,443,792	3.2%	127	0.2	0.5%
Spain	368,762	0.8%	967	0.4	1.0%
South Korea	320,259	0.7%	7410	2.4	6.8%
Taiwan	181,010	0.4%	8055	1.5	4.2%
Czech Republic	941,152	2.1%	70	0.1	0.2%
Hungary	616,011	1.4%	98	0.1	0.2%
USA	789,940	1.8%	6380	5.0	14.4%
UK	980,164	2.2%	870	0.9	2.4%
Central- and South-America	228,349	0.5%	9053	2.1	5.9%
Rest of EU	1,723,963	3,9%	486	1.0	2.7%
South-East Asia (incl. Hong Kong and Macao)	235,477	0.5%	8700	2.0	5.9%
Other countries (with spatial reference)	716,661	1.6%	2082	1.5	4.3%
Other countries (no spatial reference)	315,822	0.7%	excluded from analysis		
Total	**44,527,357**	**100%**	**791**	**35.0**	**100%**

Calculations based on data from Statistics Austria (2018), Environment Agency Austria & Statistics Austria (2018) and unpublished data from Österreich Werbung.

in 2016 was 6.4% of the Austrian GDP (only direct effects, without business trips) (Statistics Austria, 2019).

However, these numbers do not include the main part of the emissions generated by tourists visiting Austria from abroad. Emissions per visitor vary greatly between countries and dependent on the type of transport, as the comparison of several important countries of origin in Figs. 2 and 3 demonstrates. Table 3 shows the total amount of emissions generated by tourists from different countries and areas of origin in comparison to their total number. The result is a number of 35.0 Mt CO_2e, almost eight times the number calculated for tourism transport emissions covered by the Environment Agency Austria. If the number for personal transport in Table 2 would be replaced with this value, the amount of emissions attributed to Austrian tourism this way would be equivalent to 34.1% of the Austrian CO_2e emissions, according to the calculation method of the UNFCCC. If taking only into account CO_2, the amount of emissions caused by transport under this estimate is 20.4 Mt, and tourism's share in the country's CO_2 emissions makes up 22.6%.

Table 3 again makes clear the extraordinary differences in emissions depending on distance and transport type. As the most extreme example, tourists from Australia and New Zealand cause emissions of 14,510 kg CO_2e per trip, 200 times more than domestic tourists or visitors from the Czech Republic, who not only travel a short distance but hardly ever use aircraft for travelling to Austria. Due to these differences, a few countries and country groups make up the largest part of the total emissions. Most important in this sense are tourists from China, who take up 18.5%, despite their share in total arrivals being only 2.2%. Together, tourists from East Asia (China, Japan, South Korea, Taiwan, and Southeast Asia) even account for 40.5% of the total emissions. Another important country of origin, in terms of transport emissions, is the US, with a share of 14.4%. The numbers of these markets have been increasing significantly over the last years (Statistics Austria, 2018).

4. Discussion

4.1. Comparison of the results in the international context

With about 4.6% of the country's CO_2 emissions, the estimate for tourism in Austria presented in Table 2 is lower than the calculations of UNWTO-UNEP-WMO (2008) with 4.9% and of Lenzen et al. (2018) with 8.1%, which is surprising given Austria's high tourism intensity. Then again, this does not include the transport emissions caused by visitors on their travel outside of Austria; taking into account all these emissions too, the percentage could be up to 22.6%, much higher than the global estimates. What is apparent, in any case, is a very high share of transport

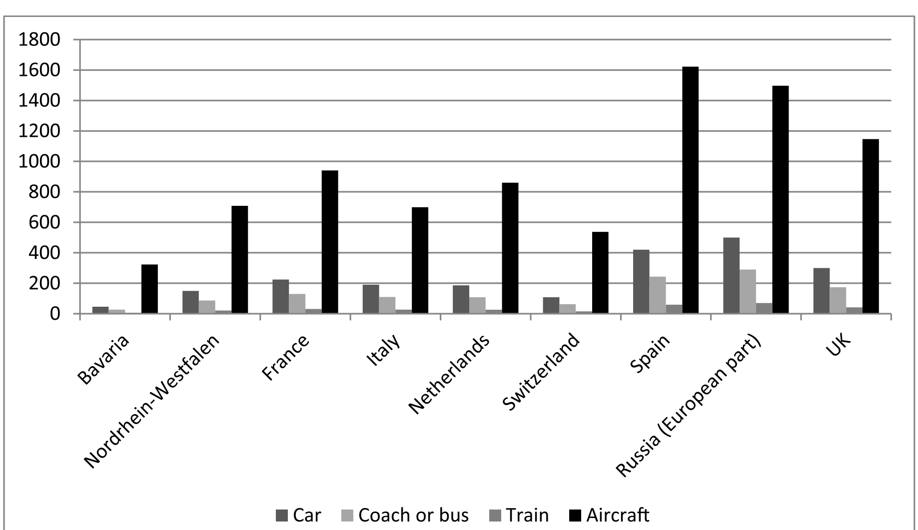

Fig. 2. Estimated average emissions generated per tourist visiting Austria from selected European countries (and German federal states) of origin, in relation to transport type, in kg CO2e.
Source: calculation based on emission data from Statistics Austria and Environment Agency Austria (2018) and distance data from Google Maps and GreatCircleMapper.

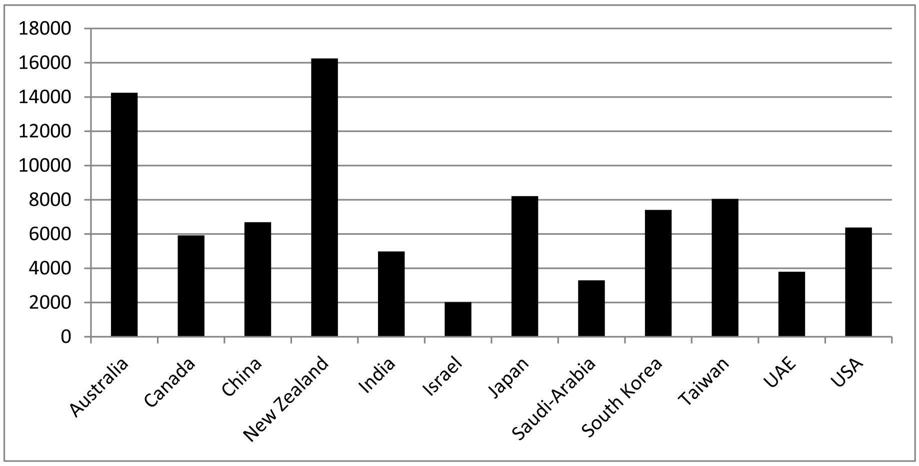

Fig. 3. Estimated average emissions generated per tourist visiting Austria from selected non-European countries, in kg CO2e.
Source: calculation based on emission data from Statistics Austria and Environment Agency Austria (2018) and distance data from GreatCircleMapper.

emissions, above the international average. Taking the figures of Table 2, the share in Austria is above 94%, and when considering the international transport emissions from Table 3 it rises to around 99%, above the global estimates of between 49% (Lenzen et al., 2018) and 75% (UNWTO-UNEP-WMO, 2008).

In comparison to other countries or regions, regardless of the methodology applied, the share of tourism in overall CO_2 emissions in Austria is clearly higher than in countries with lower tourism intensity like Romania with a share of CO_2 emissions of 2.7% in 2008, according to an input-output analysis by Surugiu et al. (2012). On the contrary, the share in Austria is considerably lower than in island nations and territories, which are highly dependent on visitors arriving by plane or cruise ships like the Greek island of Crete (Vourdoubas, 2019), the Maldives (BeCitizen, 2010), New Zealand (Patterson & McDonald, 2004) or most Caribbean islands (Gössling, 2012). The share of Austrian tourism of 4.6% of the national CO_2 emissions without considering international transport, is also lower than in Portugal, with an estimated share of 10% in the years 2000–2008 (Robaina-Alves et al., 2016). However, the share of 5.3% of the Austrian tourism industry in the country's overall greenhouse gas emissions is similar to the result of 5.2% for the case of Switzerland estimated by Perch-Nielsen et al. (2010); however, in making this comparison one has to consider the time difference (the study was based on data from 1998 to 2004) and the fact that in the case of emissions caused by air travel, all international aviation by Swiss airlines was included.

In most of the remaining European countries no comparable studies exist to date; research in countries like Germany and the Netherlands has been mainly focussed on quantifying the emissions caused by the residents' international travel (De Bruijn et al., 2010; Schmied et al., 2009) – an approach, which was recently applied in Austria as well (Kapeller et al., 2019; Prettenthaler et al., in press) – instead of focussing on the national tourism industry. Comparability of the results to international studies is further obstructed by the differences in methodologies, as outlined in the Introduction, as well as by the studies' respective limitations, especially due to the availability of relevant data. The following subchapter will discuss in detail the limitations of the present approach.

4.2. Limitations of the findings

As it was stated in the methodology and the findings section, the results of this first destination-based analysis on carbon intensity of Austrian tourism are rough estimates, based on a series of assumptions, to make up for the lack of data relevant to the topic. First of all, regarding the calculations using emission data per economic activity the assumption was made that tourism's share in each economic activity is as high as in the economic calculation of the tourism satellite account. However, its share in emissions might be different; for instance, only general data on personal transport services were available in the indications on the tourism satellite account's calculation, without any further information on type of transport. The emission data of the Austrian Environment Agency, on the other hand, do contain data on different transport services. Thus, more detailed data of the tourism satellite account could reveal if, for example, tourism's share is higher in air traffic, which would considerably increase the emissions attributable to the sector. However, this still would leave open the question if the shares of tourism regarding the economic importance of these activities can be compared to their carbon intensity. In this context, a much more detailed study would be required, which might consist in the selection of representative samples for each economic activity.

In the case of transport emissions of tourists arriving in Austria, there are several problems with accuracy as well. First of all, there is the problem of lacking information for 0.7% of tourist arrivals. Secondly, distance data might be considered relatively accurate in the case of small countries or German federal states. However, in the case of countries which are grouped together in the tourism statistics of Statistics Austria, distance data is rather vague. In this case, a more detailed insight in micro data of these statistics would prove helpful. However, vague assumptions regarding distance would remain in the case of larger countries. For example, there is an important difference between the emissions generated by a flight from the East coast of the US or a flight from California. There might be two ways to solve this problem, either by realizing an independent survey or integrating a question on exact provenance in the T-MONA survey of the Österreich Werbung, or, as Unger et al. (2016) have shown in the case of Alpbach, utilize local tourism register data from selected municipalities, representative of different types of tourism regions (e.g. cities, winter sport areas, spa towns, etc.) in the nine Austrian states.

Another problem lies in the quantification of emissions per type of transport. The introduction to this paper already mentioned discrepancies among different studies in the context of the quantification of the contribution of air transport. However, also in land transport, there can be different values in each country, depending on factors like the age and specific models of vehicles, or production of energy used by trains. Just between Austria and Germany there are important differences in the values given by the respective environmental agencies (Environment Agency Austria, 2018; Umweltbundesamt, 2018). In order to achieve more accurate values, it would be necessary to obtain data from at least the most important European countries of origin. In a further step, possibly in combination with an approach similar to the study of Unger et al. (2016), with the application of GIS it could be modelled how much emissions are generated by the tourists, depending on where they are travelling from (this, however, was beyond the scope of the present study). Finally, it can be assumed that many tourists, especially those from outside Europe, do not only visit Austria but are carrying out round trips, making stops in several countries, as it is shown by the fact that only 45% of tourists from the US responded having come to Austria by aircraft, according to the 2017/18 T-MONA survey. In this case, it can be argued that emissions should be shared among these different countries of destination, which would significantly lower the emissions attributable to Austrian tourism alone. However, this is not possible using currently available data sources. Questions in this regard might be integrated in the T-MONA survey or in a separate survey on tourism transport emissions.

4.3. Implications for public policy and tourism stakeholders

The preceding paragraphs make it clear that it is not possible, right now, to calculate an accurate value of emissions generated by the Austrian tourism sector, due to a lack of relevant data. Thus, the first implication that can be drawn from this study is to integrate these aspects in existing statistical registers and surveys. The new Austrian tourism strategy "Plan T″, presented in 2019, already contains initiatives in this regard, with the objective of integrating indicators relevant to climate change mitigation into tourism statistics (BMNT, 2019), in line with recommendations made by the UNWTO (2016). However, the indicators specifically proposed in the Plan T only mention gastronomy and accommodation businesses, which leaves out transport, which, as this study has shown, is by far the most important generator of tourism-related greenhouse gas emissions. For a thorough assessment of tourism's impact it would therefore be necessary to include transport-related indicators in tourism statistics; this might be accompanied by an extensive study to define places of origin and travel routes. This would not only permit a more accurate calculation of travel distances, but would also make it possible to integrate data on emission factors for the main countries of origin and transit. Thereby, in the ideal case a permanent monitoring of the emissions caused by the Austrian tourism industry could be established. This would reveal if policies and programs destined at lowering emissions are successful.

Despite the insecurities related to the findings of the calculations made in this study, there are a few core insights, which are so pronounced and clear, that it can be expected that they would not change significantly in a more accurate study with a better availability of data: First, the bulk of emissions is made up by tourism transport; it is rather probable that the figure given in Table 2 is too low than too high, as explained at the beginning of the discussion section. Second, in the case of tourism transport, there are extreme differences, depending on distance travelled and mode of transport. In this context, small percentages of tourists travelling long distances by plane make up large shares of the total amount of emissions. These insights are in line with most studies mentioned in the introduction to this study (with the exception of Friesenbichler, 2003, who attributes less importance to tourism transport).

These insights imply that while emission reduction measures in other areas like accommodation and gastronomy should not be disesteemed, tourism transport clearly is the single most important area for mitigating the impact of the Austrian tourism industry on climate change. This means, first of all, increasing the share of travellers arriving by bus and train, the least carbon-intensive transport types. E-mobility might reduce emissions as well, however, driving an electric car in 2016 generated 94 g CO2e per km per person (Environment Agency Austria, 2018), which is still much more carbon intensive than public transport (cp. table 1), due to the indirect effects related to its production. It is necessary to make travelling particularly by train more attractive and to create possibilities to move around within tourism towns and regions without the necessity of a personal vehicle. Travel by aircraft should be made less attractive and research on alternative drive technologies for air transport should be fostered; in general, less attractive conditions for conventional fossil fuels might incentive the development of alternative fuels or at least lead to higher efficiency (Gössling & Scott, 2018; Peeters, 2017). In this context, it has to be questioned if it is reasonable, from an ecologic point of few, to work on increasing visitation from non-European markets, especially in Asia, as the current Austrian tourism strategy (BMNT, 2019) proposes. Regarding tourists from nearby markets, it would further be important to stop the trend to shorter lengths-of-stay, which means that more and more single trips are necessary to achieve the same number of overnight-stays. Reversing this trend would therefore decrease transport emissions without lowering total revenue of tourism regions (cp. Gössling et al., 2019). For a more detailed description of emission reduction measures, which can be taken in destination management see Gössling and Higham (2020), who discuss the importance of shifting the perspective of management approaches from volume to value, in order to move towards high-value, low-carbon and economically resilient destinations.

5. Conclusion

Tourism is one of the most important economic sectors in Austria. In the context of global, European and national emission reduction targets, it is therefore important to reduce emissions generated from this sector. In order to be able to do this, first of all, it is necessary to know how much emissions are caused now and which activities are the most important contributors. This study presents an attempt to calculate the amount of greenhouse gas emissions that can be attributed to the sector, following a destination-based approach. That means, it takes into account not only emissions generated within the country, but also looks at transport-related emissions generated abroad by tourists visiting Austria. A first realization when carrying out the study was that there is a lack of relevant, accurate data that can be used to calculate tourism's importance regarding greenhouse gas emissions. As a result, the analysis had to be based on a series of assumptions; the findings therefore can be seen as rough estimates. In order to calculate and, in a next step, continually monitor tourism's carbon intensity, the inclusion of relevant indicators in existing tourism statistics and surveys and the tourism satellite account would be helpful, especially regarding data on tourism transport. Moreover, an extended study on places of origin, travel routes and transport modes of tourists visiting Austria can be highly recommended. Despite the insecurities related to the results of the estimates made in this study, some important results are very clear and pronounced, so that it can be expected that they contain a high degree of credibility. In the first place this relates to tourism transport being by far the main contributor to tourism-related greenhouse gas emissions. In the second place, regarding tourism transport, most emissions are caused by air travel from faraway destinations. Flights within Europe and visitors arriving by car also play a significant role. Tourism stakeholders and governments on the federal, state and municipal level can thus be urged to work on limiting these emissions, by fostering public transport, both for arriving at the destination and mobility within tourism regions, and focussing marketing initiatives on domestic tourism and nearby markets.

CRediT authorship contribution statement

Franz Prettenthaler: The initiative for this research was first taken by, In the further research process, Christoph Neger: In the further research process, Christoph Neger then carried out most of the analysis and writing of the first draft, while the other authors took on a supportive role and participated in the supervising of the draft and the discussion of the results. **Stefan Gössling:** jointly participated in the conceptualization and outline of the study. **Andrea Damm:** jointly participated in the conceptualization and outline of the study.

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