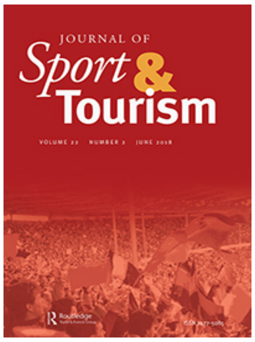

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The carbon footprint of active sport tourists: an empirical analysis of skiers and boarders

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The carbon footprint of active sport tourists: an empirical analysis of skiers and boarders

Pamela Wicker

Department of Sport Economics and Sport Management, German Sport University Cologne, Am Sportpark Muengersdorf 6, 50933 Cologne, Germany

ABSTRACT
This study estimated the annual carbon footprint of active sport tourists caused by snow-sport-related travel in the context of day trips, vacations, training courses, and competitions in 2015. Information about individual travel behaviour, sport profile, environmental consciousness, and socio-economic characteristics was collected using a nationwide online survey of adult skiers and boarders living in Germany ($n = 523$). The average annual carbon footprint of snow sport tourists was 431.6 kg of carbon dioxide equivalent emissions in 2015. Boarders had a higher carbon footprint than skiers. Regression analyses revealed that income and number of snow days had a significant positive effect on annual carbon footprint, while environmental consciousness was insignificant. This finding can be explained with the value–action gap and the low-cost hypothesis, suggesting that environmental attitudes were not associated with pro-environmental behaviour in terms of a lower carbon footprint because snow-sport-related travel was perceived as a high-cost situation by respondents. Segmenting respondents by snow-sport-related travel behaviour yielded two clusters, frequent travellers (56% boarders) and occasional riders (43% skiers), which differed with regard to annual carbon footprint, club membership, number of snow days, and performance level. This study contributes to the literature on active sport tourism and carbon footprinting.

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Climate change; carbon dioxide emissions; environmental consciousness; pro-environmental behaviour; snow sport

Introduction

Climate change and global warming are caused by greenhouse gas emissions with a significant part of these emissions being attributed to transport and travel (IPCC, 2007). Carbon dioxide makes up the largest share (76.6%) of all anthropogenic greenhouse gas emissions (Intergovernmental Panel on Climate Change [IPCC], 2007, 2014). The overall warming influence of these greenhouse gas emissions is expressed in carbon dioxide equivalent emissions (CO_2-e) and reflects the *carbon footprint* which can be estimated for persons, households, organisations, and countries (Franchetti & Apul, 2013).

Global warming leads to melting snow and ice (IPCC, 2014) which is problematic for snow sport resorts (e.g. Dawson & Scott, 2013; Moen & Fredham, 2007). Negative consequences are already observable these days: for example, in the 2015/2016 season of the

CONTACT Pamela Wicker p.wicker@dshs-koeln.de

Alpine Skiing World Cup, several races had to be cancelled because of lack of snow, including St. Anton (Switzerland), Levi (Finland), Zagreb (Croatia), and Ofterschwang (Germany). Importantly, lack of snow does not only affect competitive skiers, but also recreational riders. Snow sport tourists were found to respond to snow scarcity by travelling to ski areas that remain operational, but may be further from the source markets (Dawson, Scott, & Havitz, 2013; Rutty et al., 2015).

Such behavioural adaptation can be problematic because travelling further is likely associated with higher emissions causing global warming which, in turn, negatively affect the snow sport industry. While the negative effects of climate change and global warming on winter sport resorts and the skiing industry have already been studied from both the supply side (e.g. Moen & Fredham, 2007; Scott, McBoyle, & Minogue, 2007) and demand side (e.g. Dawson et al., 2013; Pickering, Castley, & Burtt, 2010), carbon dioxide emissions caused by snow-sport-related travel have not yet been examined.

The purpose of this study is to analyse the annual carbon footprint of active snow sport tourists. The focus of the research is on active, adult alpine skiers (short form: skiers) and snowboarders (short form: boarders) living in Germany – a country which has winter sport resorts in medium altitude mountains (up to 1500 m above sea level), but suffers from increasing temperatures and humid winters with less snow (Federal Environmental Office, 2015b). Specifically, the present study examines direct emissions of German residents caused by travelling to ski or snowboard in the context of day trips, vacations, training courses, and competitions within Germany and/or to other countries in 2015. This study advances the following three main research questions: (1) What is the annual carbon footprint of active skiers and boarders? (2) What factors determine the annual carbon footprint, i.e. why do some individuals have a higher/lower carbon footprint than others? and (3) Into what groups can snow sport tourists be segmented based on their travel behaviour? The various parameters needed to calculate the carbon footprint and other information about skiers and boarders were assessed in a comprehensive online survey. This study contributes to the body of research examining active sport tourism and the developing literature on environmental consciousness and pro-environmental behaviour in sport.

Theoretical framework and literature review

Skiers and boarders as active sport tourists

While 'a unified view of sports tourism may be unattainable' (Weed, 2009, p. 625) because of a variety of concepts and definitions, this research uses the definition advanced by Gibson (1998, p. 49) who defined sport tourism as 'leisure-based travel that takes individuals temporarily outside of their home communities to participate in physical activities, to watch physical activities, or to venerate attractions associated with physical activities'. One dimension of sport tourism is *active sport tourism* which refers to 'people who travel to take part in sport' (Gibson, 1998, p. 45). What Gibson (1998) called active sport tourism was referred to as *sports participation tourism* by Weed and Bull (2004).

The conceptual framework proposed by Gammon and Robinson (2003) further distinguishes between a hard and a soft definition of active sport tourists. The hard definition includes participation at a competitive sport event, while the soft definition relates to recreational participation in sport. For the latter, skiing is explicitly noted as an example, reflecting the notion that the majority of skiers and boarders participate for recreational rather than competitive purposes (Alexandris, Kouthouris, Funk, & Giovani, 2009).

According to Gibson (1998, p. 53), 'research on the active sport tourist is scarce, usually descriptive, and typically atheoretical'. Fifteen years later, Tomik (2013, p. 14) came to a similar conclusion when stating that 'scholarly publications on active sport tourism are fairly scarce'. Previous research has concentrated on economic effects while largely neglecting environmental aspects (Weed, 2009). Thus, it is worthwhile examining active sport tourism, and in particular snow sport tourism, from an environmental perspective. Existing research looking at environmental aspects of active snow sport tourism has focused on various topics, such as environmental responsibility (e.g. MacIntosh, Apostolis, & Walker, 2013), awareness of environmental problems (Weiss, Norden, Hilscher, & Vanreusel, 1998), attitudes towards climate change (Pickering et al., 2010), behavioural adaptation to climate change (e.g. Dawson et al., 2013; Rutty et al., 2015), perceptions of voluntary environmental programmes (Needham & Little, 2013), effect of environmental conditions on ski lift ticket sales (Shih, Nicholls, & Holecek, 2009), and the role of environmental certification in destination choice (Unbehaun, Pröbstl, & Haider, 2008). While these studies yielded valuable insights, the carbon footprint of active (snow) sport tourists has not yet been investigated.

The concept of carbon footprint

The conceptual discussion takes into account that this research examines the carbon footprint of individuals rather than organisations or countries. The concept of carbon footprint is rooted in the ecological footprint which was first conceptualised by Wackernagel and Rees (1996). The ecological footprint is referred to as 'the biologically productive land and sea area required to sustain a given human population expressed as global hectares' (Pandey, Agrawal, & Pandey, 2011, p. 137). The carbon footprint is defined as 'the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product' (Wiedmann & Minx, 2008, p. 4). It is measured in grams, kilograms, or tons CO_2-e and, thus, also includes other greenhouse gases by converting their emissions into CO_2-e (Franchetti & Apul, 2013). Hence, the carbon footprint seems to be a hybrid concept in the sense that the term *footprint* is borrowed from the ecological footprint, while it is more of a global warming indicator from a conceptual perspective which is also reflected in its unit of measurement (CO_2-e) (Pandey et al., 2011). Hammond (2007) correctly noted that footprints are typically spatial indicators, i.e. they are measured in hectares or square metres. Thus, the carbon footprint is actually more of a *carbon weight* than a footprint.

Conceptual confusion is also caused by the various concepts and definitions of carbon footprint that are available in previous research, but not further discussed here (for an overview, see Pandey et al., 2011; Wiedmann & Minx, 2008; Wright, Kemp, & Williams, 2011). Moreover, related expressions like energy footprint (Franchetti & Apul, 2013), carbon inventory or carbon accounting (Wright et al., 2011), and climate footprint (Wiedmann & Minx, 2008) are used synonymously and may add to the confusion in the field. This study uses the expression carbon footprint as this is the term commonly used by researchers (e.g. Chard & Mallen, 2012), government agencies, media, and environmental groups (Hammond, 2007).

Measurement of carbon footprint

Carbon footprint analysis refers to the measurement of greenhouse gas emissions resulting from a person's activities; the widely accepted unit of measurement is grams, kilograms, or tons CO_2-e (Franchetti & Apul, 2013; Pandey et al., 2011; Wiedmann & Minx, 2008). Different types of emissions can be considered for such an analysis. Previous research distinguished between three scopes of emissions (Franchetti & Apul, 2013; Pandey et al., 2011). Scope 1 emissions include direct emissions from the progress of a process (Wiedmann & Minx, 2008), such as emissions from mobile sources like vehicles (Franchetti & Apul, 2013). In snow sports, these would include emissions caused by commuting and travelling to winter sport destinations.

Scope 2 emissions are indirect emissions which are linked with energy consumption and purchased electricity (Franchetti & Apul, 2013; Pandey et al., 2011). In the context of snow sports, these would include emissions caused by the electricity needed to operate snow guns and ski lifts. Scope 3 emissions are all indirect emissions that occur within the life cycle of a product (Franchetti & Apul, 2013; Pandey et al., 2011). Such a life cycle analysis includes emissions occurring from the resource extraction, manufacturing, and distribution stage to the use, end-of-life, and waste management stage (Franchetti & Apul, 2013). Examples for snow sports would be emissions caused by manufacturing skis, snowboards, and ski lifts as well as their respective waste management.

Greenhouse gas emissions and parameters to estimate the carbon footprint are typically obtained through travel survey information, because 'travel-based surveys are the most effective way of […] capturing the emissions associated with […] travel made by individuals' (Mathez, Manaugh, Chakpour, El-Geneidy, & Hatzopoulou, 2013, p. 133). However, surveys should only ask questions that respondents are able to answer. This precondition affects the scope of emissions considered in this study: since active snow sport tourists are unlikely to know the life cycle emissions caused by manufacturing skis and boards (scope 3) or the level of indirect emissions caused by operating ski lifts and snow guns (scope 2), this study only examines direct emissions caused by travelling to winter sport destinations (scope 1). These emissions can be estimated based on information about individual travel distances and transportation means (Mathez et al., 2013).

Empirical evidence on the carbon footprint of sport tourists

Previous research estimated the carbon footprint of sport tourists from the perspective of sport events and sport teams. Starting with sport events, prior studies documented, for example, that the total carbon footprint for event visitation amounted to approximately 560 tons CO_2-e for the 2004 FA Cup final in the UK (Collins, Flynn, Munday, & Roberts, 2007), 1260 tons CO_2-e for the 2004 Wales Rally (Collins, Jones, & Munday, 2009; Jones, 2008), 144,120 tons CO_2-e for the 2007 UK stages of the Tour de France (Collins, Munday, & Roberts, 2012), and 165 tons CO_2-e for the 2014 World Orienteering Championships (Scrucca, Severi, Galvan, & Brunori, 2016). When dividing the total carbon footprint for the whole event by the number of event visitors (own calculation), the corresponding carbon footprints per person per event are approximately 7.67 kg CO_2-e per spectator for the FA Cup final (Collins et al., 2007), 20.2 kg CO_2-e per spectator for the 2004 Wales Rally (Jones, 2008), 50.5 kg CO_2-e per spectator for the UK stages of the Tour de France (Collins et al., 2012), and 25.4 kg CO_2-e per person for the World Orienteering Championships (Scrucca et al., 2016).

The above studies differed in terms of emissions included, subjects of investigation, and data collection methods. Most studies included direct emissions caused by travelling to and from the event (Collins et al., 2009, 2012; Jones, 2008) and to some extent also indirect emissions (Collins et al., 2007). Some studies were unclear about the type of emissions considered (Scrucca et al., 2016). The subjects investigated differed in the sense that some studies were limited to spectators (Collins et al., 2007; Collins et al., 2012), while others included participants (i.e. competitors, teams; Jones, 2008) and also staff members in addition to spectators (Scrucca et al., 2016). With regard to data collection, some studies relied on information from official sources like stadium owners and the city council (e.g. Collins et al., 2007), while others used survey data from visitor interviews (e.g. Collins et al., 2012; Jones, 2008).

Turning to sport teams, previous research estimated, for instance, that the carbon footprint for the away games of two community-based ice hockey teams in Canada for the 2010/2011 season was 20 tons CO_2-e (Chard & Mallen, 2012). The carbon footprint for spectator and team travel for varsity sport events at a Canadian University amounted to 960 tons CO_2-e for spectators and 630 tons CO_2-e for teams (Dolf & Teehan, 2015). The average carbon footprint per spectator per event was 24 kg CO_2-e and 59 kg CO_2-e per team member per event (Dolf & Teehan, 2015). While the latter study was based on life cycle emissions because the respective emission factors were available in North America, the former was unclear about the type of emissions considered. Both studies relied on survey data to assess travel information (Chard & Mallen, 2012; Dolf & Teehan, 2015).

Existing research has provided valuable insights into carbon footprint analysis in sport tourism. Nevertheless, some shortcomings can be observed. First, most previous studies provided evidence on the carbon footprint of active sport tourists using the hard definition; i.e. the focus was on competitive sport events and passive participation, i.e. spectators visiting those events. Studies including active participants only examined a specific event or specific games, not their overall participation over a specific period. The present research investigates the carbon footprint of active sport tourists according to the soft definition, i.e. individuals who travel because of recreational sport participation, which has not yet been studied. This neglect is likely due to the fact that individual behaviour is more complex and more difficult to assess; a sport event and specific teams represent clear boundaries and facilitate extrapolations.

Second, the review confirms earlier observations by Gibson (1998) that research is mainly descriptive in nature; individual or aggregate carbon footprints were calculated without analysing influencing factors using inferential statistical methods. Third, and related to the second shortcoming, is the atheoretical nature of previous research (Gibson, 1998) in the sense that no theoretical explanations were provided as to why some individuals have a higher carbon footprint than others. This study attempts to address these shortcomings by theoretically discussing and empirically examining a set of factors that affect an individual's carbon footprint.

Factors affecting the carbon footprint

Since there is no theory or theoretical model available that explains the determinants of an individual's or a tourist's carbon footprint, the present research advances potential influencing factors. An intuitive determinant of carbon footprint may be an individual's environmental attitudes and level of environmental consciousness, respectively. The term environmental consciousness encompasses a variety of environmental aspects and orientations, such as subjective perceptions of environmental damage, emotional reactions, information and knowledge about environmental problems, attitudes towards political environmental measures, and general value orientations (e.g. Preisendörfer, 1999; Rannikko, 1996). Taking these aspects into account and following the conceptualisation by Preisendörfer (1999), environmental consciousness represents a *general* attitude with cognitive, conative, and affective components. While the cognitive component captures individuals' understanding of potential threats resulting from environmental damage, the conative component includes individuals' willingness to act. The affective component reflects individuals' emotional reactions to environmental problems (Preisendörfer, 1999).

The question is how environmental attitudes and consciousness are formed. Following Kollmuss and Agyeman (2002), many models of pro-environmental behaviour share the assumption that environmental attitudes are affected by environmental knowledge. This relationship is supported by existing research on skiers: Pickering et al. (2010) found that 78% of surveyed skiers believed that global warming would adversely influence the ski industry, indicating that skiers know about the negative effects of climate change. Another study documented that ski tourists were more aware of environmental problems of ski tourism than locals depending on ski tourism (Weiss et al., 1998). In terms of behavioural adaptation, 69% of respondents would visit the resorts less often in the event of very little natural snowfall (Pickering et al., 2010). Thus, skiers seem to know that using snow guns is not environmentally viable and are willing to change their behaviour accordingly.

The relationship between environmental attitudes and pro-environmental behaviour is a core component of many theoretical models of pro-environmental behaviour, such as the model of ecological behaviour and rationalist models of pro-environmental behaviour (Kollmuss & Agyeman, 2002). Likewise, the theory of planned behaviour suggests that attitudes are an antecedent of behaviour – among other antecedents (Ajzen, 1991). Applying these concepts to the present study, an individual's level of environmental consciousness represents attitudes towards the behaviour. An individual's snow-sport-related travel and the resulting carbon footprint represent the actual behavioural outcome in the sense that a low carbon footprint reflects pro-environmental behaviour. Consequently, the assumption would be that the more environmentally conscious people are, the more environmentally friendly they behave which would be reflected in their carbon footprint. In line with the above explanations, the first hypothesis reads as follows:

H1: Environmental consciousness is negatively associated with annual carbon footprint.

Income is likely another influencing factor because travelling to winter sport destinations can be costly. For example, Gilbert and Hudson (2000) showed that both skiers and also non-skiers faced economic constraints, which represented the major limitation for both groups when compared with various other constraints, such as time, family, and intrapersonal constraints. Previous research documented that members of skiing clubs spent on average €1700 per year for practising their sport (Wicker, Breuer, & Pawlowski, 2010). Expenses do not only include clothing and equipment, but also travelling to skiing facilities and lift passes. Consequently, individuals with higher income can afford travelling more or further and using more convenient travel modes which may result in a higher carbon footprint. These aspects are covered in the second hypothesis:

H2: Income is positively associated with annual carbon footprint.

Another determinant may be an individual's level of performance. In previous research, level of performance (Wicker et al., 2010) and ski seriousness, i.e. how serious individuals practise their sport (Hungenberg, Gould, & Daly, 2013) were found to have a positive effect on ski-related spending including travel expenses. Moreover, recreational skiers who practise their sport seriously may travel further to reach resorts that meet their expectations (e.g. black piste, mogule piste) as advanced skiers were found to be more critical of the skiing facilities (Richards, 1996). Similarly, competitive skiers may be more likely to travel further in order to reach the skiing destinations where competitions take place. Since travelling affects the carbon footprint, individuals with a higher level of performance are expected to have a higher carbon footprint:

H3: Level of performance is positively associated with annual carbon footprint.

Method

Data collection

Primary data were collected using an online survey of adult (≥18 years) active skiers and boarders living in Germany. The target group was German residents travelling to ski or snowboard within Germany and/or to other countries. Given this target group, an online survey with convenience sampling strategy was used for data collection. This strategy was preferred for two reasons. First, the goal was to target German residents and not tourists at a specific ski resort who could also come from other countries. The reason for not including foreigners was the use of an emission factors table (Federal Environmental Office, 2014; see next section for more explanations) which only applies to Germany. Other countries report different emission factors because, for example, people drive different cars. The second reason is the length of the questionnaire in combination with detailed questions about travelling activities for the whole year 2015. It was assumed that it is more convenient for respondents to complete the survey at home where they have time to recall their travel activities (i.e. destinations, transport means) and also the opportunity to look up travel distances on the internet.

The online survey software Sosci Survey was used to transform the questionnaire into an online survey (www.soscisurvey.de). The survey was online from 7 January to 31 March 2016 and was posted on several Facebook sites resulting in a convenience sample. Altogether, 1597 people clicked on the link, 860 started the survey, and 563 completed it. During the data cleaning, 40 cases were removed for various reasons, including respondents living in Austria or Switzerland (18), inactivity in 2015 (16), people younger than 18 years (4), and implausible combinations of answers, such as the number of years skiing/snowboarding exceeding the respondent's age (2). After the data cleaning, the final sample of $n = 523$ was used for the empirical analysis.

Questionnaire and variables

Table 1 gives an overview of the variables used in this study. The survey started with a set of questions about the respondent's sport profile, including the type of sport (*Ski*, *Snowboard*, *Both*), the number of years the sport has been practised (*Years*), whether the respondent is a member of a winter sport club (*Club*), the number of days the respondent was skiing/snowboarding in 2015 (*Snowdays*), the average number of riding hours on these days (*Ridehours*), and the self-assessed level of performance (*Performance*). Similar questions about individuals' sport profile, including a five-point scale to measure performance level of skiers (Pickering et al., 2010), have already been applied in previous research (Wicker et al., 2010).

Ski- and snowboard-related travel was assessed in the middle part of the survey and referred to the year 2015. It was assumed that respondents would still be able to recall their 2015 snow-sport-related travel activities at the beginning of 2016. Following Franchetti and Apul (2013), boundaries are needed for carbon footprint analysis: this study was restricted to direct emissions (operational boundary) caused by snow-sport-related travel of active skiers and boarders living in Germany (organisational boundary) in 2015 (temporal boundary). Skiing and snowboarding, respectively, had to be the main reason of travel.

Table 1. Overview of variables.

Variable	Description	Scale
CF_total	Annual carbon footprint of snow-sport-related travel in 2015 (in g CO_2-e); sum of the four partial CFs	Metric
LN_CF	Natural logarithm of *CF_total*	Metric
CF_daytrip	Partial carbon footprint for travelling in the context of day trips in 2015 (in g CO_2-e)	Metric
CF_vacation	Partial carbon footprint for travelling to vacations in 2015 (in g CO_2-e)	Metric
CF_course	Partial carbon footprint for travelling to training courses in 2015 (in g CO_2-e)	Metric
CF_comp	Partial carbon footprint for travelling to competitions in 2015 (in g CO_2-e)	Metric
Ski	Individual is only a skier (1 = *yes*; 0 = *no*)	Dummy
Snowboard	Individual is only a snowboarder (1 = *yes*; 0 = *no*)	Dummy
Both	Individual practices both skiing and snowboarding (1 = *yes*; 0 = *no*)	Dummy
Years	Number of years the sport has been practised	Metric
Club	Club membership (1 = *yes*; 0 = *no*)	Dummy
Snowdays	Number of days skiing/snowboarding in 2015	Metric
Ridehours	Average number of skiing/boarding hours per snow day	Metric
Performance	Level of performance (1 = *beginner*; 2 = *blue piste rider*; 3 = *red piste rider*; 4 = *black piste rider*; 5 = *competitive athlete*)	Ordinal
Env_conscious	Environmental consciousness (additive index obtained by adding up the 7 items in Table 2 and dividing them by 7; range 1–5)	Metric
Male	Gender of the respondent (1 = *male*; 0 = *female*)	Dummy
Age	Respondent's age (in years)	Metric
Age_sq	Age squared (=Age * Age)	Metric
Edu_low	Highest educational level is below A-levels (1 = *yes*; 0 = *no*)	Dummy
A-levels	Highest educational level is university entrance qualification (1 = *yes*; 0 = *no*)	Dummy
University	University or university of applied sciences degree (1 = *yes*; 0 = *no*)	Dummy
Income	Individual monthly net income (in €)	Metric
Postcode	Postcode area (Germany has 10 postcode areas; from 0 to 9; resulting in 10 post code dummies)	Dummy

This study distinguished between four different travel purposes: competitions, training courses, vacations, and day trips (without overnight stay). The same set of questions was used to assess travelling associated with each purpose: first, respondents were asked if they travelled to competitions, training courses, vacations, and day trips in 2015. If so, they were asked for the respective number of trips they undertook for each purpose in 2015. Then they were asked to provide detailed information about each trip including destination, distance travelled (one-way), and means of transport. This study used the following seven transport means of the German Federal Environmental Office (2014) which were provided in a drop-down menu: passenger car (including vans), coach, railway (long-distance traffic), urban bus, railway (local traffic), tram/underground/city railway, and plane (not provided for day trips).

If respondents stated that they travelled by plane, they were asked to state the flight hours instead of the distance travelled because they should be more likely to know and recall the former. Flight distance was assessed through google maps using information about the airport of departure and the destination; if the destination was not properly provided, the flight hours were used to approximate the travel distance by multiplying them by 1000 as the average speed of passenger aircrafts is approximately 1000 km/h (Durchschnittliche.de, 2016). Moreover, respondents were asked for the airport of departure, the distance to the airport, and what means of transport they used to get to the airport. The length of the questionnaire varied between 4 and 6 pages depending on the number of competitions, training courses, vacations, and day trips respondents have undertaken in 2015 which had to be listed one after the other in the survey.

Then, the respondent's level of environmental consciousness was assessed using an established scale which has been originally developed by Preisendörfer (1999) and further validated by Diekmann and Jann (2000). This scale consists of seven items in total whose concrete wording and descriptive statistics can be found in Table 2. It includes affective (items 2, 3, and 4), cognitive (items 1 and 5), and conative components (items 6 and 7) and captures an individual's *general* level of environmental consciousness that is supposed to be less affected by current political events (Preisendörfer, 1999). Note that the fifth item was reverse-coded to potentially identify respondents simply clicking through the survey without carefully reading the statements. This item was recoded that it fits the other items in the sense that the higher an individual scores on the item,

Table 2. Environmental consciousness scale ($n = 523$).

No.	Item (1 = strongly disagree; 5 = strongly agree)	Mean	SD	Cronbach's α
1	There are growth limits that our industrialised world has already passed or will reach soon	3.84	0.91	.85
2	It worries me when I think about the environmental circumstances under which our children and grandchildren have to live	3.73	1.06	
3	When reading newspaper articles about environmental problems or watching respective TV programmes, I am often disgusted and angry	3.46	1.01	
4	If we continue like previously, we are heading towards an environmental disaster	3.78	0.99	
5	In my opinion, the importance of environmental problems is exaggerated by many environmental activists (reverse-coded: 1 = strongly agree; 5 = strongly disagree)	3.56	0.95	
6	It is still a fact that politicians do not do enough for protecting the environment	3.77	0.94	
7	In favour of the environment we all should be prepared to cut back on our standard of living	3.67	0.95	
	Env_conscious (additive index)	3.69	0.66	

the higher his/her level of environmental consciousness. The construct reliability was assessed using Cronbach's α which was .85 and, thus, above the suggested threshold of .7 (Nunnally & Bernstein, 1994). As the construct can be considered reliable, the seven items were converted into an additive index (*Env_conscious*) by adding up the items and dividing the sum by seven.

The questionnaire finished with a set of questions measuring the respondent's socio-economic characteristics including gender (*Male*), age (*Age*), highest educational level (*Edu_low*, *A-levels*, *University*), personal monthly net income (*Income*), and postcode (*Postcode*).

Calculation of annual carbon footprint

Individual carbon footprint was computed using information about distances travelled and means of transportation used for travelling in the context of day trips, vacations, training courses, and competitions. The seven transportation means provided in the survey – passenger car, coach, railway (long-distance traffic), urban bus, railway (local traffic), tram/underground/city railway, and plane – were converted into emission factors. These emission factors reflect the CO_2-equivalent emissions which occur when one person travels 1 km with the respective means of transportation. To take differences between countries and peculiarities of geographic areas into account, Pandey et al. (2011) recommend using national emission tables.

This study used the emission table provided by the German Federal Environmental Office (2014). This table reports emission factors and average degree of capacity utilisation by transport mean (Table 3). These emission factors capture direct emissions (scope 1) including carbon dioxide emissions and emissions caused by other greenhouse gases (i.e. methane and nitrous oxide) which are converted into CO_2-e. The emission table of the Federal Environmental Office (2014) is the only table available in Germany that can be used to calculate carbon dioxide equivalent emissions and a carbon footprint, respectively.

While such an official table with emission factors by transport mean is required to estimate the carbon footprint, it is associated with limitations. Recall that travelling in another country would require a different table of emission factors (Pandey et al., 2011). Since the present emission factors only refer to the use of transport means in Germany, travel activities which may occur in another country are not considered, such as commuting at the skiing resort (e.g. using a ski bus) and travel from the airport or train station to the ski resort.

Table 3. Emission factors and average degree of capacity utilisation by transport mean (Federal Environmental Office, 2014).

Transport mean	Emission factor (in g CO_2-e)	Average degree of capacity utilisation
Passenger car	139	1.5 persons per car
Coach	30	60%
Railway (long-distance traffic)	43	50%
Railway (local traffic)	72	27%
Urban bus	74	21%
Tram/underground/city railway	74	19%
Plane	196	76%

Taken together, the annual carbon footprint (*CF_total*) for each individual in 2015 was estimated using the following formula:

$$\begin{aligned} CF = \Bigg[& \sum_i (\text{Distance day tri p}_i * \text{Emission}_i) + \sum_j (\text{Distance vacation}_j * \text{Emission}_j) \\ & + \sum_j (\text{Distance airport vacation}_j * \text{Emission}_j) \\ & + \sum_k (\text{Distance course}_k * \text{Emission}_k) \\ & + \sum_k (\text{Distance airport course}_k * \text{Emission}_k) \\ & + \sum_l (\text{Distance competition}_l * \text{Emission}_l) \\ & + \sum_l (\text{Distance airport competition}_l * \text{Emission}_l) \Bigg] * 2, \end{aligned} \tag{1}$$

where i represents the number of day trips; j the vacations; k the training courses; and l the competitions in 2015. In short, the distances (in km) were multiplied by the respective emission factors per person kilometre (in gram CO_2-e; Table 3). Since one-way distances were assessed in the survey, all emissions were multiplied by 2.

Empirical analysis

The empirical analysis was three-fold. First, descriptive statistics were provided to give an overview of the sample structure and the carbon footprint. Second, log-linear regression models (ordinary least squares) were estimated to analyse the determinants of an individual's annual carbon footprint. Since the distribution of *CF_total* was positively skewed, the natural logarithm was used to make the variable closer to the normal distribution (*LN_CF*). In the regression models, all variables from Table 1 were entered as independent variables (except the partial CFs). For age, the squared term (*Age_sq*) was included to allow analysing non-linear relationships between age and carbon footprint. The models also controlled for the region the respondent lives in using postcode dummies as the area of living may affect the carbon footprint. People living in the North of Germany are likely to travel further to reach skiing facilities as not all German states have medium altitude mountains, skiing facilities, and snow in winter.

The independent variables were checked for multicollinearity using correlation analyses and variance inflation factors. This check showed that there were no indications of multicollinearity as all correlations (except for *Age* and *Age_sq*) were below the threshold of .8 and all variance inflation factors below 10 (Hair, Black, Babin, & Anderson, 2010). However, although below .8, the correlation between age and income ($r = .698$; $p < .001$) affected the models as coefficients turned insignificant when both variables were included. Hence, two separate models were estimated; the first model included income, the second model age and its squared term. Both models were estimated with heteroscedasticity consistent standard errors (White, 1980).

Third, a two-step cluster analysis was run to identify different segments of snow sport tourists based on their snow-sport-related travel behaviour. The annual carbon footprint and the number of competitions, training courses, vacations, and day trips individuals have undertaken in 2015 (including zeros) were used as segmentation variables. Afterwards, analyses of variances (ANOVA) were run to analyse whether the identified clusters were significantly different from each other in terms of snow-sport-related travel behaviour, sport profile, environmental consciousness, and socio-economic characteristics. An α-level of .05 was used for all statistical tests.

Results and discussion

Table 4 displays the summary statistics. Starting with the respondent's socio-economic characteristics, 58.7% of respondents were male. On average, they were 28.6 years old and earned €1383 net per month which is equivalent to the average net income of a private household in Germany (Statista, 2016). Altogether, 34.0% of respondents had a university entrance degree (A-levels) and 44.2% a degree from a university or a university of applied sciences. The sample structure was similar to previous research documenting that active snow sport tourists were mainly male, relatively young, i.e. between 18 and 44 years, and well-educated (Alexandris et al., 2009; Hungenberg et al., 2013; Richards, 1996). Average level of environmental consciousness was 3.69 on a five-point scale.

Turning to the sport profile, 40.1% of respondents were skiers, 37.5% boarders, and 22.4% practised both sports. On average, respondents have practised their sport for over 16 years. Respondents perceived their level of performance as relatively high (M = 3.7 on a five-point scale): only 2.9% considered themselves beginners or blue (i.e. rather flat) piste riders, 24.1% regarded themselves as red (i.e. medium difficult) piste riders, 70.2% had no problems when riding on black (i.e. steep and difficult) pistes, and 2.9%

Table 4. Summary statistics (n = 523).

Variable	*M*	SD
CF_total	431,620.11	507,569.27
CF_daytrip	61,907.41	131,919.63
CF_vacation	332,301.18	453,999.12
CF_course	30,961.30	86,196.20
CF_comp	6450.22	40,863.72
LN_CF	12.56	0.99
CF_ski	332,189.13	276,642.92
CF_snowboard	519,234.76	661,425.74
CF_both	463,312.70	504,107.22
Ski	0.401	–
Snowboard	0.375	–
Both	0.224	–
Years	16.68	10.31
Club	0.268	–
Snowdays	16.43	14.05
Ridehours	5.72	1.10
Performance	3.73	0.57
Env_conscious	3.69	0.66
Male	0.587	–
Age	28.59	10.22
Age_sq	921.69	804.77
Edu_low	0.218	–
A-levels	0.340	–
University	0.442	–
Income	1382.89	1136.32

even participated in competitive races. In 2015, respondents had on average 16 snow days where they spent about 6 h on the pistes.

To give an overview of the respondent's snow-sport-related travel behaviour in 2015, 46.1% undertook day trips, 92.4% were on skiing/snowboarding vacations, 25.0% participated in training courses, and 5.0% travelled to competitions. Those who travelled for the above purposes undertook on average 4.49 day trips, 2.27 vacations, 1.44 training courses, and 1.77 competitions. A detailed analysis revealed that independent of the travel purpose, passenger cars were by far the most often used means of transportation. On average, the respondents' travel behaviour resulted in a total annual carbon footprint of 431.6 kg CO_2-e per person for 2015 – which would be equivalent to one flight from Munich to Moscow. The largest part of annual carbon footprint came from travelling to vacations ($M = 332.3$ kg CO_2-e) and undertaking day trips ($M = 61.9$ kg CO_2-e). The annual carbon footprint of boarders ($M = 519.2$ kg CO_2-e) was higher than that of skiers ($M = 332.2$ kg CO_2-e) and people practising both sports ($M = 463.3$ kg CO_2-e).

When comparing the average annual carbon footprint of skiers and boarders ($M =$ 431.6 kg CO_2-e) to per capita carbon footprint figures of passive sport tourists travelling to once-off sport events, the annual figure of the present research is much higher. For example, it is approximately 56 times higher than the carbon footprint per spectator at the 2004 FA Cup final (Collins et al., 2007), 21 times higher than the carbon footprint per spectator at the 2004 Wales Rally (Jones, 2008), and 8.5 times higher than the carbon footprint per spectator at the 2007 UK stages of the Tour de France (Collins et al., 2012). The annual figure of the present study is 17 times greater than the per capita carbon footprint (including spectators, participants, and staff members) of the 2014 World Orienteering Championships (Scrucca et al., 2016). Thus, active and regular sport participation seems to be associated with a higher carbon footprint than passive sport consumption of once-off events. However, snow-sport-related travel is only a minor contributor (3.9%) to a person's total annual carbon footprint which was found to be approximately 11 tons CO_2-e in Germany (Federal Environmental Office, 2015a).

Table 5 reports the results of the log-linear regression models analysing the determinants of carbon footprint. Put differently, the regression analysis indicates who is responsible for the highest environmental impacts. Both models explain approximately 16% of the variation in annual carbon footprint. The two models yield similar results in terms of coefficients and significant effects, suggesting that the estimations are robust.

The results show that the effect of the environmental consciousness index is negative, but insignificant ($p > .05$). Thus, the first hypothesis must be rejected. This means that in the context of the present study, the assumption that environmental attitudes translate into pro-environmental behaviour cannot be empirically supported. Put differently, if environmental attitudes (i.e. an individual's level of environmental consciousness) resulted in pro-environmental behaviour in terms of a significantly lower carbon footprint, then the effect would be negative *and* statistically significant. However, the effect of environmental consciousness was insignificant.

This finding can be explained with the 'environmental value–action gap' (Blake, 1999, p. 268) which conceptualises differences between environmental attitudes and pro-environmental behaviour (Blake, 1999; Yates, 2008). Thus, people who consider themselves environmentally conscious do not necessarily demonstrate environmentally friendly behaviour (Becken, 2004; Yates, 2008). This finding is in line with some existing

Table 5. Results of the log-linear regression analyses for annual carbon footprint (*LN_CF*).

	Model 1		Model 2	
	Coeff.	*t*	Coeff.	*t*
Constant	10.7622	24.4132***	10.0515	16.9229***
Ski	REF	REF	REF	REF
Snowboard	0.2609	2.0131*	0.2488	2.1811*
Both	0.1990	1.9829*	0.1892	1.8212
Years	−0.003	−0.0471	0.0003	0.0585
Club	0.1448	1.0756	0.1528	1.1532
Snowdays	0.0195	2.5585*	0.0192	2.5160*
Ridehours	0.0630	1.4231	0.0569	1.2859
Performance	0.1756	1.9425	0.1575	1.7735
Env_conscious	−0.1107	−1.6492	−0.1165	−1.7246
Male	−0.1423	−1.5907	−0.1202	−1.4129
Age	–	–	0.0554	1.8535
Age_sq	–	–	−0.0006	−1.7905
Edu_low	REF	REF	REF	REF
A-levels	0.0823	0.6431	0.0767	0.5928
University	0.1030	0.8267	0.0755	0.5735
Income	0.0001	2.0724*	–	–
Postcode 0	0.6773	2.0100*	0.6053	1.7481
Postcode 1	0.6374	1.8824	0.5934	1.7289
Postcode 2	0.7937	2.6152**	0.7925	2.5457*
Postcode 3	0.5499	1.9776*	0.5458	1.9464
Postcode 4	0.6428	2.6001**	0.6134	2.4169*
Postcode 5	0.6335	2.5615*	0.6003	2.4041*
Postcode 6	0.7595	2.5650*	0.7209	2.3665*
Postcode 7	0.4955	1.8477	0.4739	1.7037
Postcode 8	REF	REF	REF	REF
Postcode 9	0.6440	2.1977*	0.6301	2.1318*
R^2	0.1618		0.1610	
F	4.6963		5.4514	
p	<0.001***		<0.001***	

Notes: Displayed are the non-standardised coefficients; models estimated with robust standard errors.
REF = reference category.
**p* < .05.
***p* < .01.
****p* < .001.

studies indicating that ski tourists would not change their behaviour although being aware of environmental damages (e.g. Weiss et al., 1998), while other studies reported that individuals would adapt their behaviour (e.g. Pickering et al., 2010).

The question is why an environmental value–action gap can be observed in snowsport-related travel. The low-cost hypothesis specifies in which situations the environmental value–action gap is particularly large (Diekmann & Preisendörfer, 2003, p. 443): ‘environmental concern influences ecological behaviour primarily in situations and under conditions connected with low costs and little inconvenience for individual actors’. Thus, it is assumed that environmental concern only leads to pro-environmental behaviour in low-cost situations, but not in high-cost situations. High-cost situations are those situations where the costs in terms of time, money, convenience, etc. of using another, more environmentally friendly alternative are perceived as too high by the individual (Diekmann & Preisendörfer, 2003). Typical high-cost situations include, for example, avoiding short-haul flights, buying a low-energy home, and regularly using environmentally friendly alternatives to private cars such as public transport (Becken, 2004; Tobler, Visschers, & Siegrist, 2012). On the contrary, separation of waste and reduced use of plastic bags tend to be low-cost situations (Tobler et al., 2012). Following this argumentation, snow-sport-related travel seems to be a high-cost situation because the costs of using a more environmentally friendly alternative, like a transportation mean with a lower emission factor than a private car, may have been perceived as too high by respondents. Existing research on ski tourists supports this notion: ski tourists were found to take home and separate waste and try to use less electricity and water (i.e. low-cost situations), while being less likely to reduce car usage (i.e. high-cost situation; Weiss et al., 1998).

The income effect is positive and statistically significant ($p < .05$). Thus, the second hypothesis can be confirmed. This finding confirms existing research documenting that economic constraints represent barriers to participation in snow sports (Gilbert & Hudson, 2000) and that practising winter sports, such as skiing and snowboarding, is cost-intensive (Wicker et al., 2010). The positive income effect indicates that individuals with high income showcased a significantly lower level of pro-environmental behaviour, as evidenced in a significantly higher carbon footprint compared with people with low income. This finding could be considered contradictory to the *luxury good hypothesis* stating that primarily affluent population groups are concerned with protection of the environment because they can afford it (Preisendörfer, 1999). While these concerns may be present within these population groups, this study indicates that they do not translate into pro-environmental behaviour.

The effect of performance level is positive, but not statistically significant ($p > .05$). Thus, there is a tendency that snow sport tourists with high performance level have produced more emissions when travelling to competitions or appropriate skiing facilities, but generalisations are not possible given the insignificant effect. Consequently, the third hypothesis cannot be confirmed. It is possible that the structure of the sample which was composed of rather advanced and experienced riders has influenced the results. It is more difficult to find statistically significant differences between performance levels when there is not much variation in performance levels (i.e. more than 70% of respondents have reported the same performance level).

Examining Table 5, further variables have a significant impact on annual carbon footprint. The effect of *Snowboard* is statistically significant in both models ($p < .05$), indicating that boarders had a significantly higher annual carbon footprint than skiers who represent the reference category. Thus, the regression results confirm that the difference in carbon footprint between skiers and boarders that was evident in the descriptive statistics (Table 4) is statistically significant. The number of snow days is another statistically significant ($p < .05$) influencing factor of annual carbon footprint, indicating that higher participation frequency significantly increased emission levels. The coefficients reveal that each additional snow day increased the annual carbon footprint by approximately 1.9%.

The significant ($p < .05$) effects of several postcode area dummies indicate that the regions where respondents live in affected their annual carbon footprint. All post code area effects have to be interpreted with respect to the reference category which is postcode area 8 – the Munich region (Southern Bavaria). This region is home to internationally recognised skiing resorts (e.g. Garmisch Partenkirchen, Oberstdorf) and is close to Austria and Switzerland which have many skiing resorts in the European Alps south of Munich. The results show that – with the exception of postcode areas 0 (Leipzig region), 1 (Berlin region), and 7 (Stuttgart region) – people living in all other German regions had a significantly higher carbon footprint, possibly because they had to travel further to reach skiing resorts.

Table 6. Results of the cluster analysis (segmentation based on snow-sport-related travel behaviour in 2015).

	Cluster 1: Frequent travellers	Cluster 2: Occasional riders	*F*
Number of cases	71 (13.6%)	452 (86.4%)	
Segmentation variables			
CF_total	1,135,953.10	320,983.73	226.545***
Number of competitions	0.63	0.00	164.601***
Number of training courses	0.90	0.27	47.565***
Number of vacations	4.06	1.79	113.845***
Number of day trips	7.76	1.17	182.299***
Additional variables			
Ski	0.211	0.432	12.627***
Snowboard	0.564	0.345	12.730***
Both	0.225	0.223	0.001
Years	18.82	16.35	3.533
Club	0.549	0.223	35.354***
Snowdays	30.54	14.21	98.179***
Ridehours	5.69	5.73	0.064
Performance	4.06	3.68	29.004***
Env_conscious	3.71	3.68	0.121
Male	0.662	0.575	1.904
Age	29.46	28.46	0.598
Edu_low	0.253	0.212	0.607
A-levels	0.296	0.348	0.725
University	0.451	0.440	0.027
Income	1,588.03	1,350.66	2.686

*$p < .05$.
**$p < .01$.
***$p < .001$.

The results of the cluster analysis are summarised in Table 6. The cluster analysis resulted in two distinct clusters which represented 13.6% (cluster 1) and 86.4% (cluster 2) of respondents. The clusters were labelled *frequent travellers* (cluster 1) and *occasional riders* (cluster 2) because respondents in cluster 1 travelled significantly ($p < .05$) more in 2015 in terms of the number of competitions, training courses, vacations, and day trips and, therefore, had a significantly higher annual carbon footprint than respondents in cluster 2. The results of the ANOVA also revealed that the two clusters were not significantly ($p > .05$) different in terms of socio-economic characteristics and environmental consciousness, but they showed significant ($p < .05$) differences with regard to sport profile. The share of boarders was significantly higher among frequent travellers than among occasional riders, while the proportion of skiers was significantly higher among occasional riders. Thus, the cluster analysis revealed that the significant difference in annual carbon footprint between skiers and boarders that was documented in the regression analyses (Table 5) can at least be partially explained by differences in snow-sport-related travel behaviour.

Moreover, the share of club members was significantly higher among frequent travellers, suggesting that club membership (which is required for participation in competitions) was associated with more travelling and a higher annual carbon footprint. Frequent travellers also had significantly more snow days in 2015 and reported a significantly higher level of performance than occasional riders ($p < .05$). This finding confirms existing research showing that skill level, ski frequency, and ski seriousness are positively related (Hungenberg et al., 2013). This research indicates that snow sport seriousness is also associated with annual carbon footprint.

Conclusion

This study was the first to estimate the carbon footprint caused by travel activities of active snow sport tourists. It contributes to the literature in at least three ways. First, and contrary to previous research which examined the carbon footprint of event participants or teams, this study attempted to analyse individual travel behaviour over a one-year period which is more complex and difficult to assess. Second, the present research also conducted an analysis of the determinants of individual carbon footprint rather than only providing an average carbon footprint and was thus more analytical in nature than previous descriptive studies. Third, and related to the analytical nature of the study, this study provided theoretical explanations for possible determinants of carbon footprint and, consequently, extended previous research which was largely atheoretical.

Having said this, the present study adds to the body of research examining active sport tourism in general and environmental topics in particular – which represent a developing area of research, particularly within active snow sport tourism. It also contributes to our understanding of some of the bigger questions in active snow sport tourism, such as questions pertaining to the long-term viability of snow sport tourism in consequence of climate change. While global warming leads to snow scarcity in skiing resorts, this research provided evidence about the level of carbon dioxide emissions which are caused by snow-sport-related travel and which, in turn, contribute to climate change. The present study indicates that such a *vicious circle* challenges the sustainability of snow sport tourism, also because active snow sport tourists who consider themselves environmentally conscious did not produce significantly fewer carbon dioxide emissions.

The findings have implications for policy, the tourism industry, and snow sport tourists. The insignificant relationship between environmental attitudes and pro-environmental behaviour indicates that bridging the value–action gap and turning high-cost situations into low-cost situations should be a key area of action which requires a joint effort of all stakeholders, including policy makers, tourism agencies, winter sport resorts, and snow sport tourists. For instance, policy makers should provide economic incentives to both supply and demand to encourage pro-environmental offers and respective consumer behaviour. Tourism agencies and snow sport resorts should use these incentives and make more environmentally friendly travel offers for snow sport tourists. Importantly, when environmental measures and programmes are in place, they must also be communicated by organisations. Existing research indicates that skiers and boarders were often not aware of environmental programmes of winter sport resorts, but would visit the resort more often if such initiates were increased (Needham & Little, 2013). Thus, consumers seem to value environmental initiatives which could be turned into a competitive advantage for snow sport providers and should be proactively communicated. Nevertheless, changing consumer behaviour will be challenging as existing research showed that behavioural intentions of winter sport tourists can be influenced only mildly by environmental initiatives of winter sport resorts (MacIntosh et al., 2013). Moreover, snow sport tourists should also reconsider their travel behaviour given that their sport is affected by climate change and global warming, which are in turn influenced by carbon dioxide emissions caused by travelling. Even though the behaviour of one individual has only a marginal impact, everybody has to contribute a small share and specifically nature sport participants could serve as role models in this regard.

This study is not without limitations. It is limited to the quality and comprehensiveness of the available table of emission factors (Federal Environmental Office, 2014), which did not include indirect and life cycle emissions, relied on an average degree of capacity utilisation, and did not distinguish between different types of cars which likely differ in their emissions. Furthermore, the presented carbon footprints may be an underestimation because commuting at the winter sport resort as well as travel from the airport or train station to the ski resort were not included. Moreover, the estimation of carbon footprint was based on the assumption that people used the same route and transportation means on the way back which may not have always been the case. However, a more detailed assessment would have increased the drop-out rate. Like all studies relying on survey data, this study tried to find a balance between the level of detail in questions and the degree to which respondents are willing to complete the survey. Nevertheless, the study may still suffer from recall bias. It is possible that some respondents had difficulty remembering and reporting all their travel activities for the whole year 2015. The detailed check of distances between destinations may have mitigated some of the inconsistencies. Another limitation may be the sampling procedure. This study was only able to use convenience sampling instead of random sampling.

Turning to lines of enquiry for future research, the insignificant relationship between environmental consciousness and carbon footprint as a form of environmental behaviour should be further examined. Even though the present finding can be explained with the value–action gap and the low-cost hypothesis, understanding what influences existing attitudes and behaviours is important for the development of intervention strategies. Future research should explore the psychological processes behind this thinking. For example, studies should analyse whether skiers and boarders feel a sense of entitlement because they spend high sums of money on this sport. Moreover, further qualitative research is needed to explore social factors, such as potential loss of identity as a skier/boarder if participants withdraw their involvement in skiing/snowboarding. Another avenue for future research would be to further examine the differences in carbon footprint between skiers and boarders, for example, by integrating questions about individuals' lifestyle into the survey or by examining intrinsic and extrinsic motives for snow sport participation. Notwithstanding the above limitations, this study was the first (to the best knowledge of the author) to estimate the annual carbon footprint caused by snowsport-related travel of skiers and boarders and influencing factors of carbon footprint.

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