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ORIGINAL ARTICLE

An economic perspective on rock concerts and climate change: Should carbon offsets compensating emissions be included in the ticket price?

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Abstract Musicians, singers and bands can use their popularity to promote various causes and products, either through endorsements or more individual initiatives. Environmental activism is becoming more widespread as humans are trying to tackle and mitigate climate change. In this paper, we ask how best a band can compensate for the carbon emissions generated by fans travelling to its shows. We first report on the various "green" initiatives and practices of the music industry. We then focus on greenhouse gas emissions that result from tours and concerts since they are one of the largest environmental impacts generated by the music industry. We take the perspective of the artist or band wishing to internalize their carbon emissions and present a model of carbon offsets in the context of rock concerts, which amounts to the private provision of a public good. In our model, bands have the option to include offsets in the ticket price or to offer voluntary offsets. To illustrate our point, we present a field study conducted by a Quebec rock band at shows in Montreal and in Europe to show how the artists can reduce the environmental impact of their concert by buying carbon credits equivalent to their fans' footprint. We show that at 1 % of the ticket price on average, the cost of carbon offsets is marginal and discuss the numerous challenges that arise for those artists wanting to engage in carbon offsetting.

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Don't it always seem to go
That you don't know what you've got
'Til it's gone
They paved paradise
And put up a parking lot
- Joni Mitchell (1970), *Big Yellow Taxi*

1 Introduction

Songs have always reflected the eras in which they were written. While nature has always been a deep source of inspiration for artists, from Antiquity to the Renaissance, the birth of the environmentalist movement at the end of the nineteenth century gave rise to a form of environmental activism in music. The song "Woodman! Spare that Tree", written in 1837 by George Morris and Henry Russel, is considered a first in the genre (Khan 2013). The rise of the environmentalist movement at the end of the 1960s and in the 1970s coincided with the release of a number of environmentally engaged songs, including many by popular artists such as Marvin Gaye, Neil Young or Joni Mitchell (see quote from *Big Yellow Taxi* lyrics above). This form of activism grew over the past decades as the popular awareness for environmental issues increased. Nowadays songs with an environmental message are a common theme in popular music, with superstars like Michael Jackson, Radiohead or Pearl Jam having all contributed to the genre. In a similar vein, artists also take part in large benefit concerts for environmental causes, such as Al Gore's Live Earth initiatives against climate change or AMA-ZONAS for the protection of the Amazonian forest and the cultural practices of its inhabitants.

Many artists as well as other stakeholders in the music industry are becoming aware of their industry's impacts on the environment. Some are trying to find ways to minimize the pollution and carbon footprint generated by their live performances, and by the same occasion create for themselves an image as an environmentally conscious, or "green", artist. Live entertainment is indeed a large industry, generating in recent years annual revenues of more than US\$20 billion dollars in primary ticket sales in the USA (Mulpuru et al. 2008). This sizeable industry also generates significant impacts on the environment. Bottrill et al. (2010) estimated the overall greenhouse gas (GHG) emissions of the UK's music industry at approximately 540,000 tonnes of CO_2 equivalent (t CO_2 e) per year—roughly equal to the annual emissions of 180,000 cars—close to three quarters of which come from live performances, including 43 % generated by audience travel alone. Influential bands and artists like U2, Radiohead, the Rolling Stones, Coldplay or Jack Johnson have undertaken various green initiatives, with corresponding varying degrees of success.

For example, Jack Johnson worked with Kokua Festival in 2010 to minimize their local and global impacts (Wittlich 2012). Other initiatives range from ecological impacts audits to buying carbon offsets, either directly out of their own ticket sales revenues or indirectly by offering fans the possibility to offset their own carbon emissions. These initiatives and their various degrees of success lead to a series of questions. What are the various options available to bands wishing to green their practices and image? What works, and why? What are the barriers to implementing a green strategy faced by a rock band?

In this paper, we survey the interactions between the music industry and environmental activism, or the actions of “green” rock bands. To our knowledge, no study exists on the practice of carbon offsetting by artists in the economic literature. Our first contribution is to provide a survey of the state of activity in the field by practitioners, borrowing among others from the literature on festivals in tourism and management studies. Our second contribution is to model the carbon offsetting decision by rock bands with a simple theoretical model highlighting the trade-offs involved in ticket pricing decisions when the carbon offsets are bundled with the ticket price and when they are bought separately by the consumer. This model allows us to make comparisons with another industry using carbon offsets, the airline industry. To top off, we present findings from an original field study in which concertgoers were asked about their means of transportation, in an effort to estimate GHG emissions related to fan travel and offsetting costs. This paper should be of interest to both economists wishing to understand the greening of the music industry as well as artists and their management teams with an environmental conscience and/or the desire to project a green image.

Carbon pricing in the music industry could also be analysed through the lens of the social status literature in sociology (see for example Podolny 1993). In that context, artists would distinguish themselves on a social scale by offering green products, such as carbon offsets, along with their main music product. This social status differentiation has the potential to increase artists’ revenues through higher ticket prices and/or larger audiences. Although not formally framed in the social status literature, our model incorporates some of its intuition by allowing for increased attractiveness of a concert due to the associated offering of carbon offsets. Non-monetary considerations may also come into play, as cultural goods may entail an element of symbolic consumption. According to the classification of cultural production by Bourdieu (1971), rock concerts would be “large-scale cultural productions” which are scarcely affected by symbolic values. Because of this and since symbolic consumption is more deeply rooted in sociology than economics, we choose to focus on monetary considerations in our analysis.

We start by reviewing the best practices in the industry at large in terms of environmental impacts, including the literature on green festivals and sporting events and the practices of venue owners and concert promoters. We then take the perspective of an artist wishing to internalize some of the externalities on the environment generated by his activities. Using a simple model, we show that carbon offsets could be bundled with the ticket price under conditions that should generally be met in the case of rock concerts. We draw insights from the parallels with the airline industry, which has been offering travellers the opportunity to offset their travel by clicking on a link after purchasing their airplane ticket. Airline companies face a high level of competition and their customers are very price sensitive, which justifies their approach to offer carbon offsets that are voluntary and not bundled with the ticket price. We then illustrate our findings using a field study we conducted at concerts by a rock band from Quebec (Canada), *Les Cowboys Fringants* ("the Frisky Cowboys"). We find that the cost of carbon offsets is marginal compared to the price of concert tickets (offsets represent on average 1 % of the ticket price), but raise the multiple challenges associated with carbon offsetting in practice. We also present results from a regression analysis to investigate the determinants of the additional willingness to pay (WTP) to attend a concert reported by fans, and especially how this WTP can be explained by the value of the carbon offsets they generate.

This article is structured as follows. The next section covers the industry's green practices. In Sect. 3, we introduce our theoretical model of carbon offsetting in the music industry. Section 4 contains the details of the field study on fan carbon footprint. Section 5 discusses the issues related to carbon offsetting and the promotion of green initiatives by rock bands, while the conclusion follows in Sect. 6.

2 Green practices in the music industry and related literature

With growing concerns over climate change and the future of our planet, businesses of all stripes are including environmental issues in their corporate social responsibility (CSR) commitment (Milne and Gray 2013). A large number of companies adopt a so-called Triple Bottom Line approach, through which they evaluate their performances not only in financial or economic terms (the classic bottom line), but also in social and environmental terms. To be meaningful, this commitment to environmental actions must be voluntary, i.e. a business cannot simply be complying with existing environmental regulations. A sizeable literature exists on why firms engage in CSR and the related question of whether CSR decreases profits, by spending resources on non-revenue enhancing activities, or actually increases profits, by raising their profile to attract customers and investors and by fostering employee and community goodwill (see among others Portney 2008; Lyon and Maxwell 2008; Kitzmueller and Shimshack 2012). The empirical evidence is mixed (Reinhardt et al. 2008), with environmental CSR being associated with poorer financial performance but increased research and development (Lioui and Sharma 2012), but also with the provision of public and private goods, though the magnitudes of these effects are not clearly identified (Kitzmueller and Shimshack 2012). Additionally, some argue that a Triple Bottom Line approach and reporting on environmental impacts are actually not beneficial to the environment, because these approaches merely reinforce business-as-usual (Milne and Gray 2013).

Music—its artistic, cultural and emotional dimensions notwithstanding—is a business. It is a big, global business and has attracted the attention of economists not only because of its size and popularity, but also because it is an interesting showcase for various standard and non-traditional economic concepts.[1] There are many players in the music industry, acting in one or both of the two main arms of the business: the music recording side and the live performance side (Connolly and Krueger 2006; Bottrill et al. 2010). Artists and bands are at the centre of the industry's structure and obviously engage in both recording and live performances, though their share of income coming from recording has dropped in recent years as consumers have moved away from CDs and turned to illegal file sharing, digital purchases on iTunes, free or paying streaming like Spotify, Rdio or Pandora and internet-based radio stations. Record companies, studios and publishers operate on the recording side, while tour promoters, venue owners and festival organizers do the business on the live entertainment one.

Like their counterparts in other industries, businesses in the music industry are also increasingly becoming concerned with environmental issues and engaging in corporate social responsibility of various sorts (United Nations Environment Programme 2010). Large companies like the "Big Three" record companies Universal Music Group, Sony Music Entertainment and Warner Music Group or the live entertainment giants Live Nation and AEG Entertainment now include environmental sustainability as one of their goals or at least provide some form of reporting on their environmental impact. Smaller companies like individual venue owners also have shown interests in greening their activities, often helped by industry associations and non-profits like Julie's Bicycle or EE MUSIC.

For a business trying to adopt environmentally friendly practices, the first step is often to assess its ecological footprint. In recent years, a number of studies and reports on the impact of the music industry on the environment came out. The UK appears to be a leader on the question, with Julie's Bicycle, a not-for-profit organization founded in 2007 that has produced a number of reports on the issue (Julie's Bicycle 2007, 2009a, b, 2010; Bottrill et al. 2010), as well as Radiohead, a hugely successful band that commissioned an audit of its North American Tours of 2003 and 2006 (Best Foot Forward 2007). Reporting on a 2007 study of the GHG emissions of the UK music industry, Julie's Bicycle (2007) and Bottrill et al. (2010) show that about 75 % of the total emissions come from live performances, of which 43 % can be attributed to fan transportation. The CO_2 emissions from music recording and CD sales thus appear to be far less important than those coming from concerts and touring, though authors warn that a full picture is hard to paint. Weber et al. (2009) estimated that digital downloads reduce emissions by 40–80 % compared to delivering music via a CD, but recent concerns about energy usage of server farms might tweak these figures (Mills 2013).

Given the importance of concert revenues for bands and the large ecological impacts of live performances, we focus in this article on concerts and touring. A parallel can be drawn with the literature in tourism management on music festivals and big sporting events. These studies tend to take the perspective of the event organizers and accordingly focus on the main issues related to the environment that

[1] These include, among others, market structure and pricing issues, the resale market of concert tickets, income distribution and superstar effects, and creation and copyright protection (Connolly and Krueger 2006; Leslie and Sorensen 2014; Sá and Turkay 2013; Courty and Pagliero 2013; Waldfogel 2013).

these organizers face, which are waste, water and energy management, transportation habits, the influence on land use and local environmental pollution (Collins et al. 2009). Australia seems to be particularly advanced in this area, with studies on the Sydney 2000 Olympic Games (Kearins and Pavlovich 2002) and the Melbourne 2006 Commonwealth Games (Harris 2012), with Mair and Laing (2012) surveying four festival organizers from Australia and two from the UK, and with Laing and Frost (2010) reporting on various green initiatives at the Peats Ridge Sustainable Arts and Music Festival, the Australian National Folk Festival or the Byron Bay Bluesfest.

Artists have less influence on venue-specific issues such as energy consumption and waste management, and as such are mainly preoccupied by the carbon footprint of their concerts and tours, and especially transportation-related CO_2 emissions (Pedelty 2012; Best Foot Forward 2007). The environmental impact generated by artists and their tours can be very significant; one only has to envision the amount of GHG emissions from planes, buses and boats needed to transport teams and equipment, and the unsustainable use of land on which the events occur. If some artists are sensitive to their impact on the environment and compensate for their GHG emissions, it should be noted that the most obvious impacts are not caused by the artists themselves but by the public travelling to attend these concerts. In their carbon audits for their 2003 and 2006 tours of North America, Radiohead concluded that fan travel and consumption made up 86 and 97 % of the emissions in their theatre and amphitheatre tours, respectively (Best Foot Forward 2007). A study performed by a Quebec band, *Les Cowboys Fringants*, echo these figures, with audience-related travel accounting for 99.5 % of total transportation emissions over a 3-year period (Dupras et al. 2008).

Some local institutional initiatives provide a framework for environmentally responsible event productions. In the UK, Julie's Bicycle's Creative Industry Green[2] is a certification scheme offered to festivals, venues and event organizers wishing to showcase their green initiatives, akin to the LEED certification of buildings and homes. In Europe, groups like EE Music[3] provide tools to event organizers to help assess energy use and reduce environmental impacts, just like the Quebec Council for Sustainable Events[4] (*Conseil québécois des événements écoresponsables*) does in Quebec. These types of approaches are completely proactive and voluntary, both for festivals organizers and artists. For event organizers, these proactive approaches have direct costs, such as the development of new infrastructure for waste management, the purchase of carbon offsets or the use of more expensive products or eco-friendly services (e.g. catering and merchandize), even if spending on more energy-efficient equipment may turn out to be worthwhile investments over time. For the artists, the direct costs are generally related to payment for carbon offsets and donations to environmental partners (Boykoff and Goodman 2009). In a cost-benefit perspective, internalization of environmental externalities is a direct cost that is not necessarily compensated and is an additional expense. This additional

2 http://www.juliesbicycle.com/services/industry.

3 http://www.ee-music.eu/.

4 http://evenementecoresponsable.com/.

expense is often the main obstacle in adopting sustainable practices for festivals organizers and artists (Mair and Laing 2012). However, beyond the partial internalization of environmental externalities, artists and organizers can also benefit directly from greener practices. These can help reinforce the distinctiveness of a market position, hence providing opportunities to charge higher prices and/or attract bigger audiences. These two effects are consistent with a theoretical literature on symbolic consumption (Podolny 1993) and partially with an empirical literature on the financial returns to green business practices (King and Lenox 2001; Molina-Azorin et al. 2009).

One of the main initiatives of artists sensitive to climate change is to offset the CO_2 emissions related to the transportation of their equipment, teams and themselves. Although this practice is not widespread, some bands also offset the carbon emissions of their public. These processes are most of the time accomplished in partnership with environmental organizations that support bands in their environmental audits and the compensation process. Generally, artists dip into their revenues to achieve this compensation. To our knowledge, the only band that marginally increased the price of its tickets to offset the emissions of the public is the Rolling Stones in 2003 (Smith 2007). For their nine concerts of the *Licks* tour in the UK, ticket prices were increased by 15 pence to compensate the average emissions of spectators, estimated according to the parameters set by their partner Future Forest. It should be noted that the approach and behaviour of Future Forest has been severely criticized for its lack of ethics (Bäckstrand and Lövbrand 2006; Smith 2007). This has fuelled debate as to whether buying carbon offsets is truly beneficial for the environment, or if it is merely a form of “greenwashing”. Greenwashing can take various forms, but generally refers to an organization providing misleading evidence regarding its environmental practices (Laing and Frost 2010; Mair and Laing 2012).

To summarize, the industry’s green initiatives are voluntary actions, are not regularized and are based on the willingness and commitment of partners. This lack of regulation has led to severe criticism of certain so-called carbon neutral tours. As an example, Coldplay was publicly lambasted after the Telegraph revealed that their carbon offsets produced by a plantation of mango trees in India turned out to be a fiasco: few trees planted survived and the locals who were supposed to manage the plantations reported not having received total payment (Smith 2007). Others point to the greenwashing and the lack of source reduction that obscured the efforts of U2 on their 2009–2010 360° tour: while the band did offset their emissions, they actually relied on air travel to transport their three massive stages instead of trying to use less-polluting alternatives like boats or trains. As a result, their first 44 concerts alone had generated an impressive 65,000 tonnes of CO_2.[5] As a point of comparison, we mention the case of Radiohead, who on its In Rainbows tour used ships as much as possible to transport heavy equipment, thus reducing emissions before resorting to offsets as a last resort to achieve carbon neutrality.[6] Besides the

[5] http://www.theguardian.com/music/2009/jul/10/u2-world-tour-carbon-footprint.

[6] See http://www.musicradar.com/news/guitars/blog-u2-vs-radiohead-in-ecology-wars-212837 for an example of the U2 versus Radiohead debates among ecologists.

general denunciations concerning fraud and colonialism, criticism also focuses on the lack of accurate data on CO_2 emissions from the transportation of spectators and, more importantly, the lack of rigorous compensation processes and regulations.

3 A model of carbon offsets

In this section, we develop a simple model to compare two ways a band can offer carbon offsets to its fans buying a concert ticket. The first way is similar to what is typically found in the airline industry. That is, an optional offset offered at the time of purchase. The second is a mandatory offset, the price of which is implicitly included in the event ticket price. This model will allow us to derive the conditions under which bundling the offset with the ticket is optimal and help bands understand if they should include mandatory offsets in their ticket price. Our model is most closely related to the literature on the private provision of public goods, of which Kotchen (2009) is the best example in our context.

Consumers are assumed to have preferences over money, attending musical events and offsetting carbon emissions. For simplicity, we assume that the utility function representing those preferences is linear in money and additively separable in all three of its arguments. We further assume that the consumer choice set is restricted to attending or not a single music event and buying or not carbon offsets for that event.

Event organizers can choose to offer the choice between these two options separately (option A) or as a bundle (option B). Given the option chosen by organizers, the incremental utility to consumer i from going or not to the concert can be represented by the function:

$$U_i(\mathbf{1}_u, \mathbf{1}_\theta) = \begin{cases} (u_i - p)\mathbf{1}_u + (\theta_i - \tau)\mathbf{1}_\theta & \text{if option A} \\ (u_i - p + \theta_i - \tau)\mathbf{1}_u & \text{if option B} \end{cases}, \quad (1)$$

where $\mathbf{1}_u$ and $\mathbf{1}_\theta$ are indicator functions taking the value 1 if the consumer buys an event ticket ($\mathbf{1}_u$) or a carbon offset ($\mathbf{1}_\theta$) and zero otherwise. u_i is the consumer-specific utility from attending the event, p is the event price, θ_i is the consumer-specific utility from buying a carbon offset, and τ is the carbon offset price. Preference parameters can be interpreted as a willingness to pay for the item it pertains to.

Under option A, the consumer can split her event and offset decision. She buys an event ticket if $u_i \geq p$ and a carbon offset if $\theta_i \geq \tau$. Under option B, the carbon offset is already included in the ticket purchase at a combined price of $p + \tau$, such that the only decision remaining to the consumer is to buy the event ticket if $u_i + \theta_i \geq p + \tau$.[7]

[7] The formulation of Eq. (1) implicitly assumes that the WTP is independent of the pricing option. That may not always be the case. For example, according to theories of collective action (Olson 1971), costs to act (or their opposite benefits from action) may be lower (higher) when participation is mandatory. In that light, the proposition derived later in the paper could be interpreted as a lower bound for choosing option B, meaning that option could be even more attractive than the result we obtain.

There is a mass 1 of potential audience. The event preference parameter is assumed to be uniformly distributed between 0 and $\bar{u}$ ($u \sim U(0, \bar{u})$), while the offset preference parameter is assumed to be uniformly distributed between 0 and $\bar{\theta}$ ($\theta \sim U(0, \bar{\theta})$). Both distributions are assumed to be independent.

The objective of the event organizer is to maximize the event profits defined as $\pi(p, m(p)) = pm(p)$, where $m(p)$ is the fraction of the potential audience that buys a ticket as a function of the ticket price. Organizers cannot observe consumer types and therefore must sell tickets at a single price. This is also the case for offsets, such that everyone is offered an offset at a unique price τ.[8] The revenues from offsets are assumed to be transferred to a third party to fund specific projects to prevent other emissions or increase carbon sinks. Hence these revenues do not appear in the objective of the event organizers.

We solve for the optimal pricing strategy under each pricing option.

Option A

Under this option, the ticket and offset purchase choices are separate for the consumer. Therefore, organizers only have to consider the ticket purchase decision to maximize event profits. Using the consumer decision rule (buy if $u_i \geq p$) and the cumulative distribution function (CDF) for u $\left(F_u(u) = \frac{u}{\bar{u}} \text{ for } 0 \leq u \leq \bar{u}\right)$, we rewrite $m(p)$ as the difference between the total consumer mass and the CDF of u at p. Hence we can write the objective of the organizers as

$$\max_p p\left(1 - \frac{p}{\bar{u}}\right) \tag{2}$$

This objective is concave and its first-order condition is $1 - 2\frac{p}{\bar{u}} = 0$. Hence the optimal price is $p_A^* = \frac{\bar{u}}{2}$ and the optimal profits are $\pi_A^* = \frac{\bar{u}}{4}$. This result is graphically represented in Fig. 1. It depicts the CDF of u. For a given price p, only consumers who have WTP at least as high as p are purchasing a ticket. Hence the profits can be represented as the area between 0 and p on the horizontal axis and between $F_u(p)$ and 1 on the vertical axis.

Option B

Under this option, event ticket and carbon offset are bundled in a single product. Consumers pay $p + \tau$, while organizers receive p (τ going to a third party to finance the offsetting activities). A similar approach can be used as in option A to define the proportion of consumers buying a ticket as a function of the combined price. As the consumer decision rule depends on the sum of two independently distributed uniform random variables ($u_i + \theta_i \geq p + \tau$), this requires first to derive the CDF of the sum of u and θ.

[8] Offset prices could be tied to the specific emissions of individual concertgoers as they are linked to specific flight distance in the airline industry. However, there is no reliable method to elicit those emissions in the case of a musical event and we consider this to be private information to the event participant.

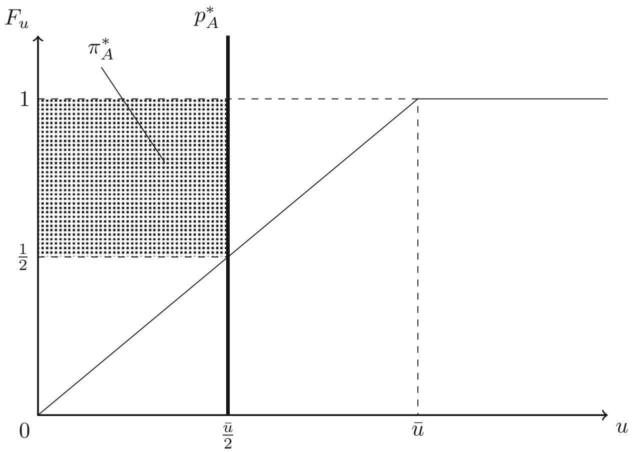

Fig. 1 Profit maximization under option A

While the distribution of a sum of independent uniform random variables with the same support is triangular, it is not the case if the distributions have different supports. In particular, we assume, in accordance with empirical estimates, that the inequality $\bar{\theta} < \bar{u}$ holds.[9] That is to say, the maximum WTP for an offset is inferior to the maximum WTP for an event ticket. We use the result of Killman and von Collani (2001) to characterize the probability density function (PDF) of that sum:

$$f_{u+\theta}(x) = \begin{cases} 0 & \text{for } x < 0 \\ x/\bar{u}\bar{\theta} & \text{for } 0 \le x < \bar{\theta} \\ 1/\bar{u} & \text{for } \bar{\theta} \le x < \bar{u} \\ \left(\bar{u} + \bar{\theta} - x\right)/\bar{u}\bar{\theta} & \text{for } \bar{u} \le x < \bar{u} + \bar{\theta} \\ 0 & \text{for } \bar{u} + \bar{\theta} \le x \end{cases} \tag{3}$$

This yields a symmetric trapezoidal PDF depicted in Fig. 2.

From the PDF, we compute the CDF of the sum of WTP:

$$F_{u+\theta}(x) = \begin{cases} 0 & \text{for } x < 0 \\ x^2/2\bar{u}\bar{\theta} & \text{for } 0 \le x < \bar{\theta} \\ \left(2x - \bar{\theta}\right)/2\bar{u} & \text{for } \bar{\theta} \le x < \bar{u} \\ 1 - \left(\bar{u} + \bar{\theta} - x\right)^2/2\bar{u}\bar{\theta} & \text{for } \bar{u} \le x < \bar{u} + \bar{\theta} \\ 1 & \text{for } \bar{u} + \bar{\theta} \le x \end{cases} \tag{4}$$

[9] Most WTP estimates for carbon offsets result from stated preferences studies, in particular contingent valuation methods. Estimates vary widely. Brouwer et al. (2008) find an average WTP of US\$30 per tonne of CO_2 e for airline passengers. But estimates in other contexts range from US\$4 (Li et al. 2004) to US\$300 (Viscusi and Zeckhauser 2006) per tonne of CO_2 e.

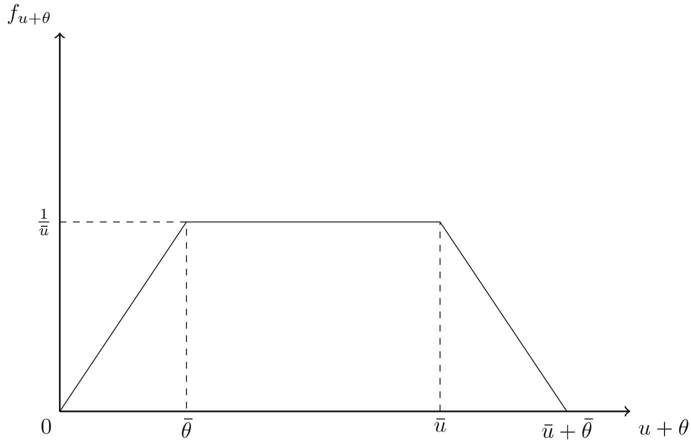

Fig. 2 PDF of the convolution of the two uniform distributions

Similarly to option A, the proportion of consumers that buy a ticket as a function of the combined price can be written as $m(p+\tau) = 1 - F_{u+\theta}(p+\tau)$. The main challenge for the maximization is that $F_{u+\theta}(p+\tau)$ has three increasing segments. Under some regularity conditions, the optimum occurs in the middle segment of the CDF. These conditions amount to the cost of offsets being not too large compared to the combined WTP and to the event WTP being large enough compared to the offset WTP. Under these conditions, we can write the organizer's problem under option B as:

$$\max_p p\left(1 - \frac{p+\tau}{\bar{u}} + \frac{\bar{\theta}}{2\bar{u}}\right) \tag{5}$$

Comparing this objective to the one under option A, it is immediately obvious what the trade-off between the two options is. Option B pushes profits downward because part of the money collected from ticket buyers must go to fund the carbon offsets (τ). However, it also pushes profit upward, because it allows capturing part of the WTP for carbon offsets by event organizers. Which of these two effects dominates will determine which option organizers should favour.

As the objective is still concave in p, we can rely on the first-order condition to maximize profits. The resulting optimal price is given by $p_B^* = \frac{\bar{u}}{2} + \frac{\bar{\theta}}{4} - \frac{\tau}{2}$, and the optimal profits are $\pi_B^* = \frac{\bar{u}}{4} + \frac{\bar{\theta}}{4} - \frac{\tau}{2} + \frac{1}{4\bar{u}}\left(\frac{\bar{\theta}}{2} - \tau\right)^2$. Similarly as for option A, the optimization problem and its solution are depicted graphically in Fig. 3.

Proposition 1 *If* $\frac{\bar{\theta}}{2} > \tau$ *then* $\pi_B^* > \pi_A^*$.

Proof It follows immediately from the subtraction of the expression for π_A^* from that for π_B^*. □

Proposition 1 has a very intuitive interpretation. It states that if the average WTP for carbon offsets is greater than the cost of carbon offsets, then event organizers should bundle the ticket with a carbon offset to maximize profits. The wedge between the average WTP for carbon offsets and their price allows organizers to increase both the price of their tickets and the overall attendance at the event.

In theory, if consumers are only self-interested, there will be under provision of carbon offsets compared to the social optimum, as they represent a public good. This, however, is of no concern to a profit-maximizing event organizer. Whether the condition of proposition 1 holds or not will depend on the degree of convexity of the cost of supplying offsets and the degree of concavity of the private benefits of offsets to consumers. The model implicitly assumes that event organisers are price takers in the offset market, which is realistic. Hence the validity of the condition of proposition 1 will depend only on the exogenous offset price and the shape of consumer preferences. Both of these are empirical matters.

In the following section, we use data collected at a rock concert to compare these measures and to highlight the plausibility of the assumptions about the relative size of parameters made in this section. We find in our survey data indications that the WTP for concert and carbon offsets could be positively correlated, if the individual carbon emissions, and hence offset costs, are related to the willingness to pay for those offsets. The qualitative impact of such a correlation on proposition 1 should be to increase the domain of prices for which the bundling option (B) is preferable. Indeed, if u and θ are characterized by a rectangular bivariate uniform distribution on the unit square, with positive covariance $\alpha/36$, then the conditional expectation of θ is $\mathbb{E}(\theta|u=x) = \frac{\bar{\theta}}{2} + \alpha\left(2x - \frac{1}{\bar{u}}\right)\frac{\bar{\theta}^2}{6}$. This expectation is larger than that for the independent WTP for carbon offsets $\left(\frac{\bar{\theta}}{2}\right)$ for most values of u, given how large $\bar{u}$ is for the WTP of concerts in general. Hence the condition of proposition 1 for favouring the bundled carbon offsets would be met for larger offset prices (τ).

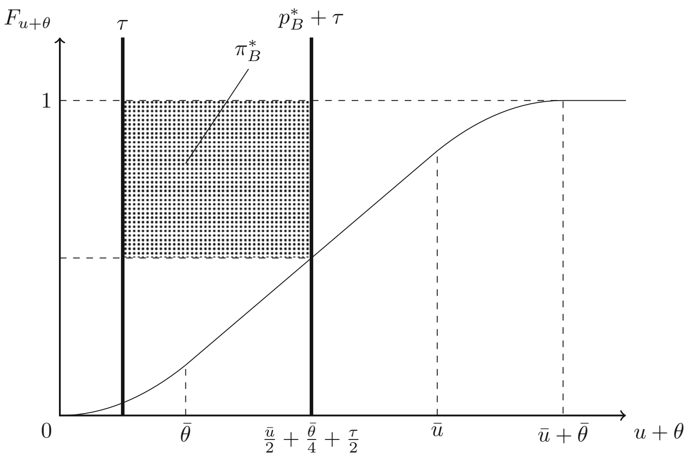

Fig. 3 Profit maximization under option B

4 Field study: surveying fans to estimate offsetting costs

We now present findings from a unique set of fan surveys done at concerts of the Quebec rock band *Les Cowboys Fringants* in November and December 2009 in Montreal (Canada), Geneva (Switzerland) and Paris and Lyon (France). We show how the survey results can be used to estimate total costs from carbon offsets needed to mitigate the effects of the CO_2 generated by fans travelling to the concert, as well as how the individual estimates of offset costs can explain the fans' reported additional willingness to pay for the concert ticket. Carbon offsetting can be part of a broader strategy to hold eco-responsible events, motivated by either the fans' demand for such events, or by a band's environmental conscience. It should be noted that there were no additional cost related to or information about carbon offsetting provided to fans during these concerts. Fans only answered a series of questions about their transportation mode, distance travelled, expenses during the concert and socioeconomic profile.

Les Cowboys Fringants are a rock band from Quebec formed in 1995 that are well known in the francophone regions of Canada—primarily in Quebec—and in French-speaking countries of Europe (France, Switzerland and Belgium). They are the best-selling French Canadian band, having sold over a million albums, and have performed in renowned venues and festivals worldwide. In 2006 they created the *Cowboys Fringants* Foundation, dedicated to the protection of the environment. Among the Foundation's activities are tree-planting initiatives to sequester carbon from tours, the conservation of ecologically valuable territories and the development of a concept of green tour (see Dupras et al. 2008).

4.1 Survey design

Considering that the atmosphere of rock concerts is not conducive to long conversations, we decided to conceive a short questionnaire that could be filled easily during the pre-concert, at intermission or after the concert. To do this, we identified the most relevant variables for estimating transportation issues. It would have been interesting to conduct a more detailed investigation, including questions to understand the environmental sensitivity, the relationship of the respondent with the band and other variables that could explain certain behaviours, but time and resources were insufficient to do this. The questionnaire included ten questions for European concerts and 12 for the one in Montreal, a number of which focused on the transportation mode used to get to the concert. The collected variables are: (1) country of residence (European concerts only); (2) age; (3) household size (as well as specifically number of people under 18 years of age in the household); (4) sex; (5) education level; (6) occupation; (7) income category; (8) transportation mode (as well as number of persons in car for those who came by car); (9) distance travelled (return trip); (10) travel time; and additionally for the Montreal concert: (11) additional willingness to pay to attend the concert; (12) additional time willing to travel to attend the concert; (13) seat section.

4.2 Data collection

At each concert, between four and six volunteers were recruited among the band's fan club. After a short interview to ensure their ability to perform the task, a member of the research team met the volunteers before the concert to distribute the questionnaires and give instructions. Each volunteer was then posted in a strategic location (e.g. near the merchandising stand or near the venue's entrance) and addressed the audience as they walked by. In total, each volunteer had about an hour to maximize the number of interviews (30 min before the concert, 15 min during the intermission and 15 min after the concert). The selection of respondents was done randomly, and the response rate was very high; few people declined the request to answer the survey. Ultimately, 251 questionnaires were completed during the concert in Paris (among 5063 spectators), 173 in Lyon (3545 spectators), 201 in Geneva (4233 spectators) and 190 in Montreal (6722 spectators). The questionnaires were collected after the concert and were transcribed manually into a database.

Table 1 contains descriptive statistics from our sample.[10] We start with general figures such as overall attendance and survey sample sizes. Each column represents one of the four cities, plus the last column, labelled "Total", which contains statistics from the four cities pooled together. We show the distribution of the main transportation modes used by fans. We notice a large proportion of car use for the concerts of Montreal, Lyon and especially Geneva, while this proportion falls below 30 % in Paris. The location of the residences of respondents, the public transportation offer, the location of the venues and the difficulties of using cars in city centres probably explain these various proportions. In the case of Geneva, the venue was located outside the city, which probably explains the low rate of use of public transportation. Note that at the Montreal concert, four spectators said they travelled from Europe by plane with the sole purpose of attending the concert. A more detailed study of their motivation would be required to justify their behaviour and deal more reliably with the data. Due to this uncertainty and the disproportionate weight of emissions of these four attendees in relation to the average, we report the Montreal numbers both with and without the air travellers, as indicated in the column headers, and we do not include them in the total figures (last column).

The Montreal concert is the only one at which respondents were directly asked about their additional willingness to pay to attend the concert. The possible answers to this question were the following categories: under CAN$25, CAN$25–50, CAN$50–75, CAN$75–100, CAN$100–125, CAN$125–150, more than CAN$150. For the figures in Table 1, the midpoint of the interval is assigned when the category was an interval, CAN$12.50 for the "under CAN$25" category and CAN$162.50 for the "more than CAN$150" category. The average extra WTP is CAN$60,[11] which is more than the average ticket value (CAN$43), and orders of magnitude more than the average cost of carbon offsets computed in the following subsections.

[10] Additional summary statistics on the sample are available in the Appendix.

[11] The median is the $CAN50-75 category (see Appendix Table 3).

Table 1 Descriptive statistics

	Montreal[a] (excl. air)	Montreal[a] (incl. air)	Paris	Lyon	Geneva	Total
Tot. attendance	6722	6722	5063	3545	4233	19,563
Sample (N)	186	190	251	173	201	818
Distribution of transportation mode (%)						
Car	65	63	29	68	80	58
Public transport	34	33	63	26	8	35
Train	1	1	6	2	10	5
Other (bike, walk)	1	1	1	4	2	2
Plane	–	2	–	–	–	–
Distance travelled (km)	77 (94) [0, 500]	286 (1431) [0, 10,000]	172 (331) [0, 1800]	105 (124) [1, 500]	157 (161) [1, 1200]	132 (217) [0, 1800]
Number of persons per car[b]	2,5 (1.0) [1, 5]	2,5 (1.0) [1, 5]	2,5 (1.0) [1, 5]	2.7 (1.3) [1, 6]	3.2 (1.5) [1, 7]	2.8 (1.3) [1, 7]
Ticket price (CAN$)	42.53 (5.63) [25, 45]	42.58 (5.58) [25, 45]	22.29 (0) [22.29, 22.29]	17.64 (0) [17.64, 17.64]	47.12 (0) [47.12, 47.12]	32.16 (12.75) [17.64, 47.12]
Extra WTP[c]	57.66 (44.31) [12.5, 162.5]	59.9 (46.36) [12.5, 162.5]	–	–	–	–

When multiple numbers are present in a cell, the first is the mean, the standard deviation is in parentheses, and the minimum and maximum are enclosed in brackets

Source: Authors' calculations based on surveys of concertgoers at four *Les Cowboys Fringants* shows in November and December 2009

[a] At the Montreal show, four respondents stated they took the plane specifically to come to the concert. Given the large impact of air travel in terms of CO_2 emissions, we report Montreal figures both including those four air travellers and excluding them. Figures in the last column (Total) do not include the air travellers

[b] For car travellers

[c] The categorical variable from the survey was transformed into a continuous variable using the mid-points of the categories as described in the text

4.3 Methodology: carbon offsets and total expenses calculation

We estimate the carbon emissions and costs of carbon offsets for each type of transportation. When a respondent stated that more than one mode of transportation was used, we assign all the travel to the most polluting mode to stay on the conservative side.[12] For car emissions, the cost of carbon offsets per person for a concert is calculated as:

[12] The ranking used, from the most polluting to the least, is as follows: plane, car, train, public transportation and others (bike and walk).

$$\mathrm{CO}_{\mathrm{car}} = (D_{\mathrm{car}}/O_{\mathrm{car}}) \times E_{\mathrm{car}} \times C \tag{6}$$

where car transportation carbon offsets ($\mathrm{CO}_{\mathrm{car}}$) are estimated using D_{car} the mean distance per car travel, O_{car} the average number of passengers by car, E_{car} the carbon emissions per kilometre for an average car and C, the cost of a tonne of carbon.

For public transportation, train and plane emissions, the cost of carbon offsets per person for a concert is calculated as:

$$\mathrm{CO}_i = D_i \times E_i \times C \tag{7}$$

where carbon offsets (CO_i) are estimated using D_i, the mean distance travelled by fans for mode of transportation i ($i \in \{pt,$[13] $train, plane\}$), and E_i, the average carbon emissions for that mode of transportation.

The total cost of carbon offsets per person for a concert, $\mathrm{CO}_{\mathrm{tot}}$, is computed as a weighted average of the mode-specific costs according to the following formula:

$$\mathrm{CO}_{\mathrm{tot}} = \sum_{i \in \{\mathrm{car,pt,train,plane}\}} \mathrm{CO}_i \times P_i \tag{8}$$

where the weights P_i are the fraction of concertgoers using transportation mode i. Note that a few respondents stated using another mode of transportation (such as walking or biking). As these modes do not generate emissions, we leave them out of the computations.

The parameters D_i, O_{car} and P_i come from our survey data. The typical emissions E_i come from various widely used estimates. The figures used are as follows, all in kg CO_2 e per kilometre: car, 0.21; public transportation, 0.19; train (Canada), 0.1; train (Europe), 0.0056; plane, 0.3 (Greenhouse Gas Protocol 2015; MEDDE 2012; Intergovernmental Panel on Climate Change 1999). Note that to be conservative, the value used for public transportation corresponds to travel by bus, which pollutes more than subway, and the value used for train in Europe is for electric lines and not the high-speed train (TGV). The monetary value used to measure the price of carbon offsets corresponds to the social cost of carbon used in the evaluation of public policy by Environment Canada (CAN\$25/tCO_2 e) (Environment Canada 2010). The social cost of carbon refers to the damage cost avoided and represents the marginal cost of emitting an additional unit of CO_2 into the atmosphere (the monetary value estimate of the damage resulting from CO_2 emissions). We feel that this value is more representative than the carbon market prices, which are subject to fluctuations based on supply and demand. The current price of a tonne of carbon is CAN\$12.10 on the Quebec carbon market (linked to the Western Climate Initiative; MDDELCC 2015).

4.4 Findings from field study

We present our findings in Table 2. As in Table 1, we show figures for each concert separately and then overall in the last column. Despite marked differences in the

[13] *Pt* is for public transportation.

Table 2 Carbon emissions and offset costs for four concerts

	Montreal[a] (excl. air)	Montreal[a] (incl. air)	Paris	Lyon	Geneva	Total
CO_2/person (kg)	8.2 (10.4) [0, 76]	71.2 (430) [0, 3000]	17.6 (39.5) [0, 342]	10.7 (16.1) [0, 84]	12.0 (17.1) [0, 126]	12.6 (25.4) [0, 342]
Total CO_2 for fan travel (tonnes)	40.8	473.5	89.3	37.9	50.8	246.3
Total offset cost (CAN$)	1378	11,962	2233	946	1269	6158
Mean offset cost/ticket (CAN$)	0.21	1.78	0.44	0.27	0.30	0.31
Mean ticket price (CAN$)	42.53	42.58	22.29	17.64	47.12	32.16
Mean ticket price, with carbon offset (CAN$)	42.74	44.36	22.73	17.91	47.42	32.47
Offset/ticket price (%)	0.49	4.18	1.97	1.53	0.64	0.96

When multiple numbers are present in a cell, the first is the mean, the standard deviation is in parentheses, and the minimum and maximum are enclosed in brackets

Source: Authors' calculations based on surveys of concertgoers at four *Les Cowboys Fringants* shows in November and December 2009

[a] At the Montreal show, four respondents stated they took the plane specifically to come to the concert. Given the large impact of air travel in terms of CO_2 emissions, we report Montreal figures both including those four air travellers and excluding them. Figures in the last column (Total) do not include the air travellers

distribution of the means of transportation used by the spectators (see Table 1), the average emissions remain substantially similar across concerts, ranging from a high of 17.6 kg CO_2/person in Paris and a low of 8.2 kg CO_2/person in Montreal. This amounts to a total level of CO_2 emitted by fans overall of 246.3 tonnes for the four concerts.

Using Eq. (8), we find that the per-person cost of carbon offsets for the four concerts varies between CAN$0.21 in Montreal and CAN$0.44 in Paris, for an average of CAN$0.31 per person. The estimate for Paris is likely to be an upper bound as we used the emissions for travel by bus for the respondents who said they used public transportation to be conservative, but subway was probably a common choice in Paris. These figures correspond to total costs ranging from CAN$946 in Lyon to CAN$1378 in Montreal, for a total of CAN$6158 for the four concerts. We note the very small per-person cost attached to carbon offsetting. At CAN$0.31, it represents a tiny fraction of the ticket price, which ranged from CAN$15 to CAN$45 in Montreal and was €27.70 in Lyon, €35 in Paris and CHF49 in Geneva.[14] The last row of Table 2 shows the size of the mean offset cost relative to the ticket price. In the context of our model from Sect. 3, it becomes clear that the cost of a carbon offset bundled with the ticket would not raise the ticket price by a significant margin, given that overall we find the offset to be 1 % of the ticket price. At the Montreal concert, fans reported being willing to pay on average CAN$60 more to

[14] The ticket prices in Tables 1 and 2 are all converted in CAN$ using the appropriate exchange rates published by the Bank of Canada.

attend the concert (see Table 1). It is safe to conclude that most ticket buyers would have bought at the minimally increased price needed to include the carbon offset.

4.5 Regression analysis: determinants of the additional willingness to pay

The last piece of our empirical analysis seeks to determine which factors are linked to the additional WTP reported by fans at the Montreal concert. This analysis is not meant to be causal, but to highlight interesting correlations. One explanatory variable of particular interest here is the individual cost related to the carbon offsets. Do people who generate higher offset costs also report being willing to pay more for their concert ticket? To answer this question, we estimate a regression model where the additional WTP is explained by the individual offset cost, as well as other control variables such as mode of transportation, age and income categories, gender, education level and occupation. Since our dependent variable is categorical, we use an ordered probit model where the top two categories of the additional WTP (CAN$125–150 and CAN$150 and above) have been grouped together due to the small number of observations in the CAN$125–150 category. For comparison, and ease of interpretation, we also present coefficients from a linear model estimated using ordinary least squares (OLS), in which we use the transformation of the categorical variable described above, where the midpoint of the category was used. The results from the OLS model are qualitatively very similar to those from the ordered probit models, which is not very surprising since the categories underpinning the dependent variable are based on dollar values and not some arbitrary scale. For our main independent variable, we use the natural logarithm of the individual offset cost, computed as described above. We find the logarithm to be more appropriate in this context since the distribution of the offset costs appears to be reasonably well approximated by a lognormal distribution.[15] Using the logarithm implies that we exclude from our estimation sample the five observations which have no emissions, hence a cost of zero; they represent a trivial fraction of the sample.

Our results are presented in Table 3, where we report the coefficients from four specifications of the ordered probit models as well as one OLS model. The offset costs are positively and significantly related to the additional WTP: It appears that the people who generate more carbon emissions, and thus whose carbon offset is higher, are also willing to pay more to attend the show, even when controlling for a number of factors. The interpretation of the ordered probit coefficients is not straightforward—we will present the marginal effects below—but we can first look at the OLS coefficient for an easy interpretation: a 10 % increase in offset costs is associated with a WTP increase of approximately CAN$0.90, all else being held equal.[16] As for the effect of the other control variables, age seems to be a more important determinant of the WTP than income is, at least based on the Chi-squared

[15] See Figure A1 in the Appendix.

[16] The OLS regression line can be plotted according to the Frisch–Waugh theorem in a scatterplot in which the residuals of the additional WTP are on the y-axis and the residuals of the logarithm of offset costs on the x-axis, where the residuals come from regressions of the variable in question on the rest of the control variables. See Figure A2 in the Appendix for an illustration.

statistics presented at the bottom of Table 3. Those statistics test for the joint significance of the age dummies and of the income dummies. The 25–34 years olds have the highest predicted WTP, and the under 18 year olds the lowest. Most of the other explanatory variables do not turn out to have statistically significant effects, except for the transportation mode by train (negative effect compared to transportation by car) and education categories in the ordered probit model (all categories have positive effect compared to primary level). Note that these findings are based on a limited number of observations, coming from one show of one rock band, so while they are probably informative for this specific band their external validity is limited, as the fan demographics of bands likely has a significant band-specific component.

In Fig. 4, we graphically present the marginal effects of the log of offset costs on the additional WTP, based on the ordered probit model with a full set of control variables as presented in column (4) of Table 3. We can see that an increase in the log of offset costs is associated with a decrease in the probability of having an additional WTP in the first two categories (under \$CAN25 and \$CAN25–50), but with an increase in the probability for the top four categories. All the marginal effects are statistically significant at a significance level of $\alpha = 5\ \%$ or less, except for the marginal effect on the \$CAN50–75 category which is significant at $\alpha = 10\ \%$.

5 Discussion

In this section, we, however, offer a discussion on the use of carbon offsets, its intricacies, ideal use and pitfalls. As part of future research on the economic analysis of carbon offsetting at music concerts, it would be possible to draw on methods widely used in environmental economics to measure the willingness to pay of individuals for market or non-market goods or services, such as the carbon offset associated with concert tickets (the equivalent of θ in our theoretical model). In environmental economics, measuring the value of non-market goods is often done through valuation methods based on the analysis of preferences and behaviours of individuals. In this case, it is assumed that individuals are the best judges of their preferences and that they choose the basket of goods that maximizes their utility, whether commercial or not. In our model, we implicitly assumed that the value concertgoers put on carbon offset was independently distributed from the value they put on the concert themselves. A more formal study of these values might prove or disprove this assumption. Our regression analysis in Sect. 4.5 seems to imply that the value of carbon offsets needed to compensate for individual emissions is positively related to the fans' additional WTP to attend the concert. If emissions are linked to the value of the offsets to the concertgoer, then our assumption of independence should be refined.

There are two broad categories of methods for identifying these values, whether the method is based on revealed or stated preferences. Revealed preferences methods are rooted in the analysis of indirect markets, reflecting the expenses engaged by individuals or households to obtain non-market environmental goods. In our case, the method of transportation costs would be of interest to highlight the

Table 3 Regression analysis (dependent variable: additional WTP, Montreal show)

Model	(1) Ord. probit	(2) Ord. probit	(3) Ord. probit	(4) Ord. probit	(5) OLS[a]
ln(offset)	0.219 (0.100)*	0.269 (0.111)*	0.228 (0.109)*	0.261 (0.115)*	9.772 (4.310)*
Age (omitted: 18–24)					
Under 18	−1.185 (0.347)**		−0.926 (0.372)*	−0.859 (0.468)	−17.601 (14.075)
25–34	0.123 (0.211)		0.030 (0.254)	−0.112 (0.292)	−0.333 (12.225)
35–44	0.639 (0.216)**		0.583 (0.304)	0.525 (0.326)	21.938 (13.971)
45–54	−0.234 (0.286)		−0.399 (0.389)	−0.761 (0.424)	−27.211 (15.646)
55–64	0.839 (0.907)		0.662 (0.945)	−0.079 (0.832)	3.902 (37.640)
Income (omitted: under CAN$15,000)					
15,000–29,999		0.866 (0.237)**	0.514 (0.294)	0.471 (0.341)	15.278 (12.124)
30,000–44,999		0.647 (0.233)**	0.264 (0.327)	0.272 (0.392)	6.168 (14.581)
45,000–59,999		1.069 (0.312)**	0.446 (0.422)	0.358 (0.506)	8.884 (19.041)
60,000–74,999		0.972 (0.494)*	0.398 (0.542)	0.404 (0.592)	12.170 (24.442)
75,000 to 89,999		1.088 (0.598)	0.927 (0.731)	0.842 (0.754)	29.554 (28.192)
Transportation mode (omitted: car)					
Public transportation	0.066 (0.183)	−0.051 (0.187)	0.023 (0.194)	0.046 (0.209)	−2.568 (8.007)
Train	−5.624 (0.361)**	−5.895 (0.359)**	−5.795 (0.393)**	−5.867 (0.500)**	−63.036 (18.505)**
Female				−0.394 (0.197)*	−11.663 (7.392)
Household size (omitted: 1)					
2				−0.132 (0.278)	−4.468 (12.123)
3				−0.145 (0.313)	−6.620 (13.162)
4				−0.527 (0.437)	−17.740 (16.510)
5				−0.040 (0.430)	−1.062 (17.213)
7				0.933 (0.496)	28.371 (19.278)
Number of under 18 in household (omitted: 0)					
1				0.185 (0.268)	3.286 (10.599)
2				0.239 (0.463)	7.524 (17.758)

Table 3 continued

Model	(1) Ord. probit	(2) Ord. probit	(3) Ord. probit	(4) Ord. probit	(5) OLS[a]
3				−0.133 (0.604)	−1.934 (20.884)
Education level (omitted: primary)					
Secondary				4.361 (0.431)**	12.638 (11.747)
College				4.377 (0.456)**	9.487 (12.024)
Bachelors and above				4.553 (0.476)**	15.080 (13.867)
Occupation (omitted: student)					
Other				0.796 (0.675)	29.430 (27.567)
Employed				0.102 (0.277)	3.609 (10.299)
Thresholds					
θ_1	−0.940 (0.257)**	−0.458 (0.290)	−0.691 (0.311)*	3.344 (0.678)**	
θ_2	−0.449 (0.248)	−0.016 (0.287)	−0.213 (0.304)	3.852 (0.679)**	
θ_3	0.264 (0.245)	0.676 (0.291)*	0.512 (0.302)	4.597 (0.672)**	
θ_4	0.629 (0.252)*	1.062 (0.301)**	0.907 (0.312)**	4.997 (0.671)**	
θ_5	1.137 (0.266)**	1.554 (0.317)**	1.413 (0.328)**	5.522 (0.688)**	65.778 (22.566)**
N	181	170	170	169	169
Pseudo-R^2	0.08	0.06	0.09	0.11	0.27
Chi^2-stat. age vars	31.05		16.63	17.56	3.29
p value age	<0.001		0.005	0.004	0.008
Chi^2-stat. inc. vars		18.2	4.41	2.67	0.52
p value inc.		0.003	0.492	0.751	0.762

In columns (1) through (4), figures presented are the estimated coefficients from ordered probit models where the dependent variable is the additional WTP of respondents, with the top two categories combined due to the low number of observations in category 6. In column (5), figures presented are the estimated coefficients from an OLS model where the dependent variable is the transformed additional WTP, where categories are assigned their midpoint value. Robust standard errors in parentheses

Source: Authors' calculations based on a survey of concertgoers at a *Les Cowboys Fringants* show in Montreal in December 2009, not including the four air travellers

* $p < 0.05$; ** $p < 0.01$

[a] In column (5), the statistics at the bottom are the R^2 and the appropriate F-statistics and p values, and the θ_5 value corresponds to the constant

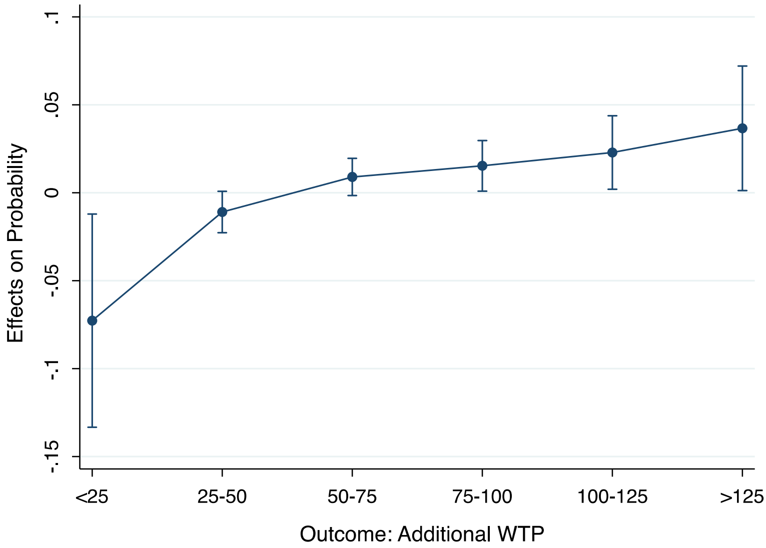

Fig. 4 Average marginal effects of log of offset costs with 95 % CIs. *Note* Average marginal effects based on estimation results from ordered probit model presented in Table 3, column (4). Confidence intervals based on standard errors computed using the Delta Method. *Source*: Authors' calculations based on a survey of concertgoers at a *Les Cowboys Fringants* show in Montreal in December 2009

additional costs incurred by the spectators to get to the concert and would add perspective on the cost of compensation. The objective of the stated preference methods, contingent valuation being the most well known, is to communicate directly with individuals by creating a simulated market in a survey. This is done in order to establish their arbitrage between the willingness to pay (or accept) for an improvement (or deterioration) of the environment. The use of such methods could help both estimate the willingness to pay of the spectators for carbon offset and elicit their payment vehicle in connection with the trade-offs presented in the model in Sect. 3.

A comparison with the airline industry is informative. While the demand for concerts is relatively inelastic as artists have some level of monopolistic power, airline companies face stiff competition. Price aggregators allow consumers to base their decisions on a wide range of comparisons, and they will often choose one company over the other even when price differences are but a mere handful of dollars. For airlines, it thus makes sense to sell offsets as not bundled with the ticket price, as they increasingly do for a number of attributes to their product: slightly better seats, checked luggage, meals, headsets, etc. Our conclusion would be that for bands that wish to use carbon offsets to compensate for their fan's travel, a bundled approach should work better than an optional, voluntary approach.

In this article, we discuss compensation mechanisms and choices available to artists in this direction. However, in the context of combating climate change it should be stressed that the voluntary offsetting is a mechanism that theoretically does not lead to optimal levels of abatement. It should ideally be used in conjunction with other emissions reduction efforts. Focusing only on compensation leads to what many call greenwashing, as mentioned in Sect. 2. This expression is used when an individual or organization puts forward its efforts in terms of sustainable development and environmental protection through marketing and communications levers, even if significant efforts are not made to reduce its own environmental impact, particularly emissions. Voluntary carbon compensation approaches may sometimes be criticized and associated with the phenomenon of greenwashing, on top of being seen as a loophole to avoid a primary effort to reduce emissions. It is therefore essential that an organization that wants to convey its carbon compensation actions can also show its work to reduce its emissions. In this way, it would ensure real consistency in its words and withdraw the maximum benefits in terms of branding. The example comparing Radiohead and U2 given in Sect. 2 illustrates the role of compensation in a broader context. If the first band used this approach as a last resort, working to reduce emissions at the source of GHG emissions, the second has been accused of greenwashing by not using alternative transportation approaches to reduce emissions and by using compensation as the only mitigation approach.

Moreover, it should be noted that the compensation mechanisms are not all equal in effectiveness. In our model and survey, we have shied away from questions of offset quality, presuming of a uniform quality and refraining from asking participants about their confidence in carbon offsets. Many organizations, including artists, offset their emissions by planting trees knowing that the growth of the tree will result in carbon sequestration. In many cases, the compensation is calculated by the carbon sequestered when the tree reaches maturity, a process that may span decades depending on the species and the planting site. Thus, during the period when the emitted carbon is not totally compensated, its action on climate is ineffective. This emphasizes the limits of carbon offsets in the context of combating climate change.

Finally, we must emphasize that our findings are the result of a survey of fans of one rock band at four concerts only. Although the questionnaire has been designed to avoid any biases, the relationship between the fans and the band could potentially affect certain behaviours. For example, because the band does not frequently perform in Europe, some spectators may have travelled over longer distances than they would for other concerts. These factors must be considered and limit the generalization of the results. Furthermore, while we used recognized sources for our estimates of carbon emissions by transportation mode and cost of carbon, there remains an uncertainty as to the accuracy of these figures. However, we always chose the conservative (i.e. more polluting or more costly) option whenever we had to make a decision in the computation of the carbon offset cost, so our cost estimate should not be biased downwards.

6 Conclusion

Rock concerts have a sizeable environmental impact. From the energy consumption needed to power sound and lighting systems, to waste management issues and carbon emissions from band, equipment and fan transportation, there are many areas to consider for a band wishing to make its concerts and tours more sustainable for the environment. In this article, we focus on the largest source of carbon emissions: fan travel. After a review of the literature and industry best practices, we introduced a model to highlight the trade-offs faced by a band wishing to offset the carbon emitted by their fans coming to their show. The model gives a theoretical condition for a profit-maximizing band for when to bundle or not carbon offsets with ticket prices. Empirically we find, under relatively plausible conditions, that a band's optimal decision should be to bundle the offset with the concert ticket and thus include the price of the offset in the ticket. This conclusion stems from the findings from a field study at four rock concerts by a band from Quebec. Our estimates of the per-person cost of carbon offsets range from CAN$0.21 to CAN$0.44, for an average of CAN$0.31. Adding 31 cents to the price of a concert ticket should not deter most fans from buying a ticket, especially given that they reported being willing to pay an average of close to CAN$60 extra to see the concert. Our estimates are also in line with the added cost of 15 pence that the Rolling Stones added to their tickets on the *Licks* tour of 2003, or with the per-fan offset costs of $CAN0.83 and $CAN0.95 that can be computed using carbon emissions estimates from the Radiohead 2006 theatre and 2003 amphitheatre tours, respectively (Best Foot Forward 2007).[17]

We also discussed some of the difficulties associated with the use of carbon offsets, not the least important being that they should be used as a last resort; to reduce environmental impacts, a band should first try to reduce emissions before compensating for its remaining emissions. Many artists have a green conscience, or at least appear to have one. How can they help? We argue that including carbon offsets in the ticket price would be a good measure. But they could also encourage fans to use more environmentally friendly ways to get to the concert, by using public transportation and cycling if possible, or carpooling if driving is necessary.

These actions, and this paper, remain limited to one form of environmental impact—carbon emissions—and its main source in the case of shows—fan travel. Furthermore, our empirical results may not be readily generalizable to the whole industry as they come from a set of surveys concerning a single band, at four concerts. Future studies should look at the others sources of impacts and emissions. The intersection of economics, culture and environmental studies has not been much studied so far. We hope many more studies will come after ours to fill this gap.

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Compliance with ethical standards

Conflict of interest Dupras is the bass player of the rock band *Les Cowboys Fringants*. Connolly and Séguin declare that they have no conflict of interest.

[17] The costs are based on the estimates from p. 8 of Best Foot Forward (2007), using the per-fan emissions and multiplying by $CAN25, the social cost of carbon emissions (C) as described in Sect. 4.3.

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