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I Believe I Can Fly—Conceptual Foundations for Behavioral Rebound Effects Related to Voluntary Carbon Offsetting of Air Travel

Christoph Kerner * and Thomas Brudermann

Institute of Systems Sciences, Innovation and Sustainability Research, University of Graz, 8010 Graz, Austria; thomas.brudermann@uni-graz.at

* Correspondence: christoph.kerner@edu.uni-graz.at

Abstract: Voluntary carbon offsets (VCO) have been introduced as a means of compensating personal carbon emissions related to travelling. Purchases of VCO have remained low in the past, but might increase in the future due to rising awareness about climate change. VCO have been assumed to increase the acceptability of flying among eco-minded people. Therefore, VCO might not only be a tool to offset emissions but also to compensate for "flight shame". Much research has been carried out to detect VCO purchasers' motives, but none has explored the potential behavioral rebound effects of VCO with regard to flying. This article contributes to the debate by presenting a conceptual framework that was developed to investigate these rebound effects. First, we present the motives that travelers have for offsetting their flight emissions. These motives already indicate the possibility of a rebound effect. Second, we discuss several conceptual ideas which should be considered for the design of empirical studies. Overall, we argue that the use of VCO might lead to unintended carbon emissions; however, isolating the specific role of VCO remains a difficult task. Nevertheless, research on behavioral rebound effects is needed to clarify whether VCO counteract sustainability in the transport sector.

Keywords: behavior change; behavioral rebound effect; carbon offsets; flight emissions; flight shame; moral licensing; travel behavior; VCO

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1. Introduction

Carbon emissions must be substantially reduced to mitigate global warming and, thus, to reduce risks to the well-being of humans. According to the fifth IPCC report [1], the current transport systems are not sustainable. The transport sector is one of the main emission sources, and travel demand has continued to increase [2]. Emissions from the transport sector comprise emissions from trade, but also civil personal transportation. Several airlines and travel agencies provide individual travelers the option of taking voluntary carbon offsets (VCO), giving them the opportunity to compensate for their personal carbon emissions. Carbon offsetting compensates for carbon emissions by financing climate mitigation measurements, e.g., the expansion of renewable energies and afforestation [3,4]. The principal idea is that VCO compensate for as much carbon emission as is caused by the initial action, which can then be considered as carbon neutral.

VCO have been praised for offering those willing to act with an opportunity to reduce their personal emissions and for promoting climate mitigation measures [5]. However, the purchases of VCO remain low. Although the exact rates are uncertain, studies estimate that the percentage of offset flights are in the single-digit range and that less than 10% of passengers have offset at least one flight in the past [6,7]. Moreover, VCO have also been criticized for several reasons. On the one hand, researchers have questioned whether the financed measures really result in the claimed offset and, thus, whether VCO are truly reliable [8]. On the other hand, the potential of VCO is restricted; no arbitrarily large

amount of carbon emissions can be offset because, e.g., the global mitigation potential of afforestation is limited [9]. Moreover, VCO have been compared to the sale of indulgences, leading to speculations that VCO could increase the acceptance for flying among climate-aware groups and might eventually lead to more flights overall [10]. For these reasons, VCO might counteract the sustainability efforts aimed at reducing the number of flights.

Unintended effects of this type have been discussed by referring to rebound effects. In an economic sense, the term "rebound effect" often refers to the fact that improvements in (energy) efficiency result in an increased use of the improved technology, and that, therefore, the potential energy savings are not fully realized [11–13]. In this paper, we argue that the behavioral side of such rebound effects also requires attention. Even when economic rebound effects emerge from an economic incentive (i.e., monetary savings due to increased efficiency, leaving the consumer with more money to spend), the question of whether the additionally available money is spent on a carbon-intense activity falls into the behavioral realm. Indeed, rebound effects have been discussed with increasing frequency from a psychological perspective in recent years, and in particular with regard to environmental impacts [14–16]. In this paper, we review the research on behavioral rebound effects and present a conceptional framework developed to further study such effects in relation to VCO associated with carbon-intense activities such as flying.

Dorner [14] defines the behavioral rebound effect as "any increase in environmental damage from a decrease in pro-environmental behaviors and increase in consumption, following a decrease in marginal environmental damage from consumption." Thus, the behavioral rebound effect suggests that environmental damage and consumption increase because pro-environmental behaviors or environmental damage decrease.

For instance, an increase in the use of electric vehicles may lead to a behavioral rebound effect, namely, to an increase in car use due to additional car trips and a modal shift towards cars [16,17]. Similarly, Coulombel et al. [15] showcase a behavioral rebound effect related to car ridesharing (i.e., when people switch from public transport to car use due to the availability of ridesharing).

Rebound effects may be distinguished by the place where the rebound effect occurs. The direct rebound effect refers to a behavioral response which is directly linked to the service used, such as driving more miles by car due to enhanced fuel efficiency. The indirect rebound effect describes behaviors which occur in response to a service that is used but which also transfers to the use of other services, such as spending the money saved due to the use of a fuel-efficient car for other carbon-intense activities [18].

Regarding the VCO of flights, both types of behavioral rebound effect seem possible. In this paper, we discuss behavioral rebounds with regard to their effects on carbon emissions: A direct rebound effect occurs if air travelers fly more due to the purchase of VCO. An indirect rebound effect would imply that travelers behave in carbon-intensive ways elsewhere after purchasing the VCO. For example, they might select a carbon-intensive SUV over a climate-friendly compact car when renting a car at the holiday resort. The economic perspective (i.e., how rebound effects have been understood traditionally [11,13]) is absent from such examples. Flights with VCO are in fact more expensive, not less, in monetary terms. However, flights with VCO are "morally less expensive" for climate-change-aware passengers, and the saved moral costs might offset the "flight shame" otherwise associated with air travel.

Still, as far as we are aware, no research has been conducted to analyze potential rebound effects with regard to the VCO of flights. Kotchen [10] argues that environmentally friendly people might prefer to purchase VCO and keep flying rather than to change their behavior and switch transport modes. Similarly, Eijgelaar [19] assumes that VCO might hamper "the willingness of individuals, businesses, tourism companies and airlines to engage in structural, technological and behavioral change" [19] (p. 12). However, research is still needed to test these assumptions.

Two studies have examined the behavioral rebound effects of carbon offset programs; however, these were related to different services, and only one of the programs was

voluntary. Harding and Rapson [20] discovered that, when they were confronted with the option to carbon offset personal energy consumption, "many individuals who voluntarily sign up for carbon offsets actually increase their consumption following adoption" [20] (p. 946). Furthermore, Günther et al. [21] analyzed the behavioral response of individuals to a corporate and thus non-voluntary carbon-offset program, namely, offsetting emissions related to showering in a youth hostel. Unlike in a VCO program, the assumption was that consumers did not directly bear the costs of corporate programs. As a result, the authors found that consumers increased their consumption after the offset program had been introduced. Moreover, the authors proposed that this rebound effect may be reduced by providing users with real-time consumption feedback.

Since rebound effects have been observed in these related fields, we argue that a rebound effect of VCO with regard to flights should be considered as a possibility. This paper contributes to further research by presenting a developed conceptual framework and discussing potential research challenges. For this purpose, we assume that VCO are reliable (i.e., VCO actually lead to the claimed emission reductions), and we set aside obligatory or cooperative carbon offsets. However, these assumptions might be revisited in future research. In recent years also non-voluntary offsets have been discussed, and some corporations have committed to pay carbon offsets for their employees. For instance, the Lufthansa Group [22] purchases carbon offsets for all their employees' business trips.

We first review findings on the motives of air travelers to purchase VCO. These motives will support the assumption that a rebound effect is plausible. Second, we present conceptual ideas about rebound effects related to VCO. In particular, we distinguish between the direct and indirect rebound effects and discuss their implications with regard to carbon emissions. Third, we discuss methodological challenges that impede the empirical study of behavioral rebounds related to VCO for air travel. Finally, we conclude that both direct and indirect rebound effects should be carefully considered, but that measuring both effects will continue to be a complex task.

2. Materials and Methods

The conceptual framework developed in this paper was based on a review of relevant literature. Keywords were defined and used to search the Scopus database and the Web of Science citation index. A main search term was selected, namely "carbon offsetting travel behavior rebound effect flying", and synonyms or similar terms were identified for each keyword in this search term. Figure 1 shows the keywords used. During the literature review process, various combinations and parts of these keywords were used. Conference papers and articles published before 2000 were excluded. Results were sorted by relevance, and the first 50 articles (note that several queries yielded many fewer than 50 results) were used to categorize the purchase motives (Section 3) and as references in the discussion on the impact of VCO on travel behavior (Section 4).

carbon offsetting	+ travel	+ behavior	+ rebound effect	+ flying
carbon offsets	traveler/traveller	behaviour	rebound	aviation
		behavioral /behavioural	change	flight
				air

Figure 1. Keywords used for the literature research. The "+" sign refers to the AND operator in search engines.

3. Purchasing Motives for VCO

Many researchers have discussed reasons for the low purchase rate of VCO. Overall, most studies have been carried out to understand how leverage points are used to enhance purchases, because they have assumed that VCO are an important component of the

transition to sustainable mobility. Therefore, most studies placed a focus on people's motives to (not) purchase VCO and asked how these might be promoted.

Unlike corporate or obligatory offsets, individuals have no obligation to purchase VCO, which might explain the low purchase rates. Theoretically, most people should have an interest in limiting their total carbon emissions, as climate change will affect all humans in some way. Thus, carbon emissions may be seen as a public good (this becomes apparent in the discussions about the distribution of the remaining carbon budget). Based on the public goods theory, each individual is motivated to take a "free ride", when "all group members can consume a public good, even those who do not bear the cost of providing the good" [23] (p. 185). From a purely rational perspective, air travelers have a good reason to reject VCO, and to get a "free ride"—or a "free flight"—as the individual decision to compensate for emissions or not has a negligible impact on the public good overall.

Moreover, low VCO purchases have been explained by pointing out the low levels of awareness about offsetting schemes. For instance, Babakhani et al. [24] argue that informing consumers about VCO would counteract this low awareness and result in more purchases, as well as counteract the consumers' negative attitudes towards VCO. Similarly, Lu and Wang [25] assume that low offsetting rates are due to a lack of knowledge and proposed measures to raise awareness. Ritchie et al. [26] claim that knowledge and awareness of global policies may increase orders of VCO, but argue that the effect of awareness is rather small as compared to the effects of other factors. In particular, awareness of VCO might vary between cultures due to contrasting social marketing strategies and differences in public discourse (e.g., between Europe and Asia) [27]. Eijgelaar [19] concludes that awareness-raising campaigns have not led to a substantial increase in the past, but that, nevertheless, raising awareness is necessary. Based on these arguments, different proposals for awareness campaigns have been made. Overall, one should take into account that highlighting the description of projects financed by VCO and emphasizing their social benefits [24] may significantly influence purchasing behavior [28]. Moreover, information sources must be credible to positively impact orders of VCO [29].

In addition, the theory of cognitive dissonance can help us better understand carbon-offsetting behavior. According to Festinger [30], people experience mental discomfort when they hold different cognitions that contradict each other. To reduce this mental discomfort, people can theoretically either change one of their cognitions or adopt a new one. Thus, a VCO purchase can be understood as one additional cognition which allows the purchaser to reduce the unpleasant feeling that arises from the dissonance between climate-friendly attitudes and climate-unfriendly actions such as flying. VCO is then used as a tool to resolve flight shame, that is, the "unease about the climate implications of air travel" [31] (p. 1). This argument is supported by findings from behavioral studies on VCO. First of all, many purchasers of VCO tend to have pro-environmental attitudes [7,32] and to feel as though they have high levels of personal responsibility [33,34]. For this reason, many purchasers of VCO seem to have two conflicting goals: they want to minimize personal carbon emissions, but they also want to travel to distant locations by airplane. VCO might be perceived as a tool that allows them to accomplish both goals.

Furthermore, VCO may be seen as a moral licensing strategy. Moral licensing describes the effect that behaving in a morally good way at some point may lead to and justify behaving immorally at another point [33]. In this way, Kotchen [10] argues that purchasing VCO (= morally good behavior) might "offset the green guilt" of customers, giving them permission to use the airplane (= immoral behavior). For this reason, VCO have been compared with the medieval sale of indulgences [8], which enabled sinners to offset their immoral behavior by paying fees to church authorities. The importance of considering moral licensing with regard to VCO is stressed particularly by Dorner's [14] argument, which states that the effect of moral licensing is largest when people hold pro-environmental attitudes. Other researchers have argued that business travelers are less likely to purchase VCO than individual travelers [27], possibly because business travelers do not consider themselves personally responsible for their flight emissions but see them as "necessary

emissions" required by their businesses and employers. Therefore, moral licensing might be triggered less often for business travels. Figure 2 gives an overview of the most prominent behavioral reasons that explain the success or lack of success of VCO.

	Why do (most) people not purchase VCO?		*Why do (some) people purchase VCO?*	
Explanatory concepts	Free-riding [23]	Awareness as precondition for consumers' ability to purchase VCO	Cognitive dissonance [30]	Moral licensing [33]
Consumers' starting position	No obligation to purchase VCO	Low awareness of VCO [24, 25]	Conflicting goals, e.g., flying and reducing carbon emissions [7, 31, 32, 34]	Pursuing an immoral action (flying) [10]
Motives	Maximizing the personal utility [23]	Making decisions based on information that is available	Releasing unpleasant feelings [30]	Justifying the immoral action by behaving morally at another point (VCO) [14, 33]

Influence on the purchase rate of VCO

Figure 2. Overview of VCO purchasing motives.

4. How Do Carbon-Offsetting Schemes Impact Behavior?

Since behavioral rebound effects have been discovered for carbon-offset programs in different domains, it is reasonable to assume that VCO also have an impact on air travel behavior and the associated carbon emissions. This assumption is supported if we consider the individual's motivation for carbon offsetting. One of the main reasons that people offset carbon emissions is moral licensing (as depicted in Figure 2), and moral licensing is believed to be one driver for rebound effects [18].

Spiekermann [35] follows this line of thought when he points to a potential rebound effect and claims that VCO may hinder the motivation "to make more substantial sacrifices to mitigate climate change" [35] (p. 927). Purchasers of VCO also seem to feel less guilty about flying [7]. These findings clearly underline the possibility that a direct rebound effect exists and, namely, that some air travelers might choose to avoid flying because they experience stronger feelings of guilt or flight shame if they have no options to offset emissions.

However, we argue that an indirect rebound effect is equally plausible. Unlike the direct rebound effect, which manifests in the decision to fly, the indirect rebound effect could manifest in any carbon-emitting activity that is behaviorally related to the decision to purchase VCO, such as taking a helicopter sightseeing flight at the vacation resort due to decreased flight shame. Because VCO could also reduce the feelings of guilt in those flying in either way, we argue that an indirect rebound effect may pertain to all purchasers of VCO, whereas a direct rebound effect may be associated exclusively with purchasers of VCO who would otherwise avoid flying. Therefore, two main groups of VCO purchasers can be identified: those who purchase offsets but do not change their behavior, and those who fly only or fly more when they can offset the emissions. Figure 3 shows the hypothesized impact and rebound effect of the introduction of VCO on flight emissions. While flight emissions caused by the direct rebound effect are offset by the respective compensating mechanisms, additional emissions caused by the indirect rebound effect are not offset.

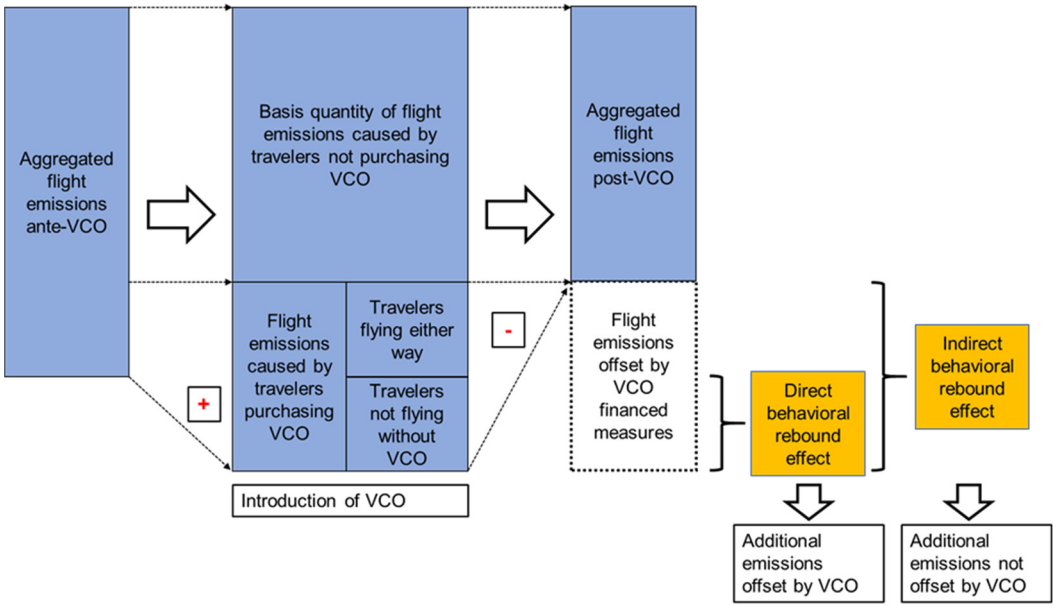

Figure 3. The impact and rebound effect of the introduction of voluntary carbon offsets (VCO) on flight emissions caused by air travelers (parts of this figure have been inspired by the classification of rebound effects of Dütschke et al. [18]).

For the sake of simplicity, we assume that emissions of travelers who do not purchase VCO remain stable. In contrast, travelers who do purchase VCO but do not change their travel behavior offset their emissions and, thus, reduce the final amount of their flight emissions. On the other hand, travelers who would not fly unless they had an opportunity to purchase VCO temporarily raise the level of aggregated flight emissions, because the absolute number of air travelers increases. If all emissions for these travelers are reliably offset, the increase in the number of air travelers does not cause an increase in the final emissions. This argument, however, is based on several assumptions: (1) there are no limits to offsetting capacities, (2) air travelers are consistent in their offsetting behavior (i.e., offsetting one flight does not lead to an absolution of guilt and "allow them" to take a non-offset flight later), and (3) the potential growth of passengers seen by allowing eco-minded people to fly does not lead to a growth across the entire airline industry, and, therefore, indirectly add to the higher number of travelers (including additional passengers who do not offset their emissions). So far, no attempts have been made to test such assumptions.

Setting these constraints aside, the direct rebound effect describes the increase in air travelers. Thus, it only concerns the subgroup of VCO purchasers who will not fly without VCO. The indirect rebound effect, on the other hand, may concern all VCO purchasers, because their purchase of VCO might morally license their carbon-intense behavior in any case.

As indicated above, the number of VCO purchasers remains uncertain, and no studies have pointed out the shares of both subgroups of purchasers. Research is needed to clarify the split between both groups. One crucial question is clearly how differently these splits would influence the final flight emissions, as well as the assessment of VCO. The brief answer is: the higher the split in the number of travelers who would not fly without VCO, the higher the increase in the absolute amount of air travelers and, in turn, the indirectly caused emissions.

Assuming that carbon offsetting is reliable, all emissions directly caused by purchasers are offset, no matter how many people additionally use the airplane. For this reason, the extent of the direct behavioral rebound effect does not influence the final amount of flight emissions. Even if the direct rebound effect was very high and incentivized many people to fly, the final amounts of flight emissions would stay at the same levels. However, if VCO are not reliable and emissions are only partially offset, the extent of the direct rebound effect is highly relevant for the aggregated amount of flight emissions.

Nevertheless, one may also argue that the direct rebound effect must be considered, not only for its influence on directly caused flight emissions, but also for its influence on the indirect rebound effect. Because the direct rebound effect influences the total number of VCO purchasers, it also simultaneously influences the emissions caused by the indirect rebound effect. This is a relevant consideration, because emissions caused by the indirect rebound effect are not offset by VCO (e.g., a helicopter sightseeing flight at the vacation resort is not offset by the initial VCO mechanism). Thus, the indirect rebound effect influences the overall amount of carbon emissions. Figure 4 shows the expected correlation between the direct rebound effect, the number of VCO purchasers and the emissions caused by the indirect rebound effect. If no direct rebound effect occurs, the number of VCO purchasers is equal to the number prior to the introduction of VCO. The stronger the direct rebound effect is, the higher the number of VCO purchasers and the number of travelers who are subject to the indirect rebound effect.

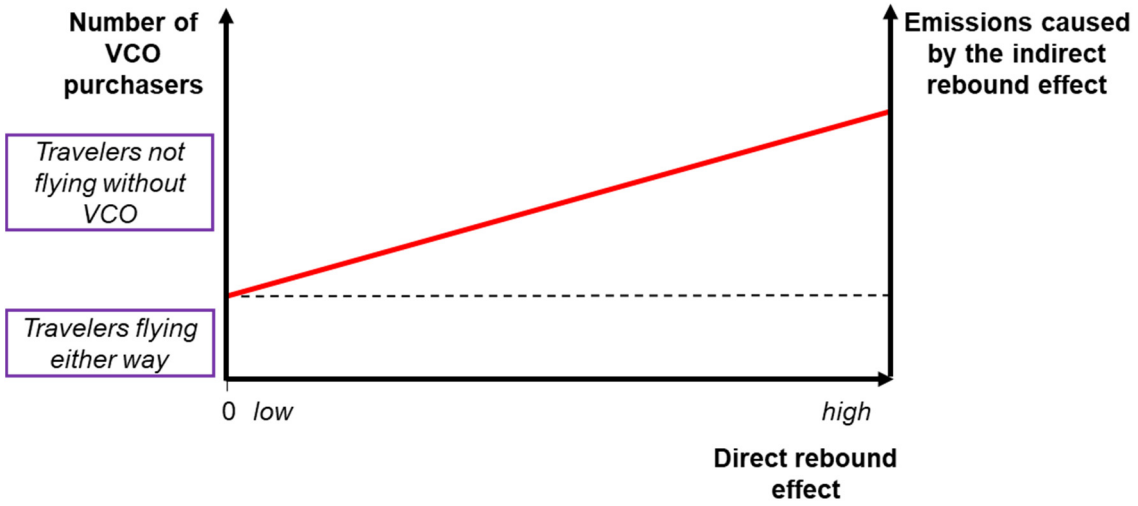

Figure 4. Hypothetical impact of the direct rebound effect on the number of VCO purchasers and emissions caused by the indirect rebound effect, assuming that the indirect rebound effect grows constantly (indicated by the red line) as the numbers of VCO purchasers increase.

5. Discussion

The conceptual considerations presented in the previous section are based on a review of studies on carbon offsetting, rebound effects, and moral licensing. While this article makes merely a theoretical contribution, and an empirical test of these considerations is beyond the scope of this paper, it demonstrates the limitations and expected challenges regarding the operationalization of these considerations in empirical studies.

One challenge is the availability of data. Airlines themselves might not have complete information regarding the share of passengers who offset their flights: VCO can be booked at several stages and from different sellers (e.g., from a travel agency rather than directly from the airline). Passengers also might simply offset their emissions individually with a provider of their choice. There is no single source for these kind of data, and the cooperation of data owners is not guaranteed. Data protection measures apply; therefore, linking actual offsets to the passengers' personal data (including their preferences, attitudes, and travel behaviors) can be problematic. Linking behavioral data to individuals, however, is necessary when investigating psychological mechanisms.

Therefore, studies on behavioral rebounds necessarily rely on voluntary participants who sign up for a respective (questionnaire) study. When studies are based on surveys among volunteers, biases are unavoidably introduced into the collected data: self-reports might not entirely reflect actual decisions, the social desirability of providing certain answers might result in overestimations of the passengers' actual green-mindedness (and

respective behaviors), and/or the recruited sample could be biased towards green-minded passengers. To address these limitations, methodological triangulation (i.e., integration of different data sources and research methods) is required.

Nonetheless, it is safe to assume that VCO purchasers can be rather directly recruited and asked to participate in questionnaire or interview studies. Their motives for purchasing VCO, the number of flights they have taken in the past, and how many of these were offset can be surveyed with the respective instruments; likewise, their attitudes and intentions can be gathered. A more difficult question is whether these travelers would take flights if they did not have the option to purchase VCO. On questionnaires and in interviews, such questions can only be addressed hypothetically, do not preclude social desirability, and the answers might be biased by the post-hoc rationalization of decisions made in the past. Likewise, gaps between the passengers' intentions and actual behaviors have been reported, although the evidence for the existence of such a gap is mixed [36,37]. The availability of VCO might also just be one of many decision factors that influences whether a person will fly or not in a given situation, and not necessarily the decisive one.

Furthermore, while it is plausible that VCO contribute to an indirect rebound effect, it remains uncertain how this effect can be measured. The indirect rebound effect could manifest in any carbon-emitting activity. Therefore, examining such potential side-effects of VCO is a complex endeavor. For instance, using a carbon-intensive instead of a climate-friendly rental car at a holiday resort might be influenced by the purchase of VCO. But choosing a car depends on a broad set of criteria (and the readily available options), which makes the influence of the VCO difficult to measure. In addition, indirect rebound effects occur when two contrasting actions are mentally interconnected (e.g., due to moral licensing) [18]. Nevertheless, these mental interconnections may happen subconsciously, making the identification of connected actions via questionnaires even more challenging.

Figure 4 indicates that a hypothetical connection exists between the direct and indirect rebound effects. It is plausible to assume that the indirect rebound effect grows proportionally to the number of VCO purchasers. However, the exact shape of the curve is still unknown and remains to be investigated (under consideration of the methodological hurdles discussed above). In particular, the ratio between the direct and indirect rebound effect might be dependent on the reasons that people purchase VCO. For example, people with pro-environmental attitudes who have the strong personal goal to reduce their emissions might be less likely to be subject to the indirect rebound effect, as they reflect upon any emission-causing activity. In contrast, people who spontaneously purchase VCO due to a guilty conscience triggered by advertising from VCO providers might be more likely to pursue emission-intensive activities elsewhere.

How behavioral rebound effects related to the VCO of flights can be mitigated or avoided also remains an open question. One approach that could be taken to answer this question could be to make adaptations to the choice architecture and to make offsets into the default options, which travelers need to de-select rather than select; this is in agreement with the concept of "green defaults" [38]. This might lead to the lower awareness about the flight being offset; therefore, passengers might not feel morally entitled to emit more elsewhere. On the other hand, when travelers know that flights are offset by default, climate-related reasons not to fly might disappear, which again might result in indirect rebound effects. The moral burden of flight shame in this way could be taken away from passengers, especially travelers with limited knowledge regarding how flights harm the climate system, who will be presented with a very convenient excuse to continue flying or even to increase their airtime.

Another option to counteract rebound effects could be to activate intrinsic motivations, which has been linked to climate-friendly behaviors in previous studies [39], and to stress the relevance of small individual contributions, as perceived powerlessness has been linked to less climate-friendly behaviors [40]. Moreover, Günther et al. [21] argue that real-time feedback about the effects of carbon intensive activities could reduce behavioral rebound

effects. In the context of rebounds related to VCO of air travel, however, the relevance of these variables has yet to be empirically studied.

6. Conclusions

The existence of behavioral rebound effects related to VCO is plausible. Still, research on this matter is lacking. In this paper, we began to address this gap. We developed conceptual foundations based on the reported motives of VCO purchasers and the impacts that carbon-offsetting schemes can have on people's behavior. Such rebound effects have been previously reported in other domains, and indications are given that moral licensing promotes rebound effects. We also discussed methodological issues that need to be taken into account when performing empirical studies on VCO.

A direct behavioral rebound effect would lead to an increase in the number of air travelers and, therefore, to a theoretical growth in the amount of emissions. If we assume that VCO are reliable, the additional emissions would be offset. Thus, one might conclude that the extent of the direct rebound effect is trivial. Nevertheless, the direct rebound effect influences the absolute number of air travelers as well as the amount of non-offset emissions caused by the indirect rebound effect (i.e., emissions caused by air travelers at a point other than the flight itself). If we assume that VCO are not perfectly reliable, the absolute amount of flight emissions would increase in proportion to the direct rebound effect.

Investigating the potential behavioral rebound effect remains challenging due to the lack of data and the subconscious interconnections that passengers might make. This, in turn, makes it difficult to isolate the specific role of VCO. In addition, results may vary depending on the research context. Nevertheless, research is needed to substantiate both the direct and indirect rebound effects of VCO with regard to flying and to clarify whether VCO cause unintended carbon emissions. The findings of this research will help to establish whether VCO are a reasonable and feasible component in the diverse set of tools used to promote more sustainability in the transport sector.

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