VOLUNTARY CARBON OFFSETS IN THE AVIATION INDUSTRY: HOW ENVIRONMENTAL KNOWLEDGE AFFECTS TRAVELERS WILLINGNESS TO PAY – A SYSTEMATIC REVIEW

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ABSTRACT

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Abstract

Although the amount of emission per passenger seat kilometer in the aviation industry is constantly decreasing through technological advancements and improved operations, the industry cannot negate its vast increase in total emissions. The driving factors behind aviation's' growing impact on the climate is the steep increase in passenger number. One mechanism which can be utilized to counteract these impacts are voluntary carbon offset schemes. By using a systematic quantitative literature review, this study reveals the overarching connections between the environmental knowledge of study participants and their willingness to pay for carbon offsets. One major gap revealed was the lack of studies cooperating with the industry, which could have provided useful data on booking and purchase behavior. Although some studies found social-demographic factors as age, gender and education to be a reasonable predictor for the WTP, the majority did not confirm these, indicating effects of the regional and cultural background of the studies. A Network Analysis revealed a separation between offset related aspects into "impacts of carbon offsets" and "offset projects types" including "co-benefits". Aside from this, two major clusters were found. One surrounding different parties' contribution to climate change, awareness and responsibility, the other forming around aspects of the new ecological paradigm and environmental impacts. Knowledge on one's own and aviation's contribution to climate change and the subsequent responsibility passenger's felt or rejected consistently played a key role in the voluntary engagement with carbon offsets. Aspects of awareness however did not consistently increase the WTP. This leads to the assumption that mere awareness campaigns might not be a suitable tool to increase adoption of voluntary carbon offsets.

Keywords: Voluntary carbon offsets, environmental knowledge, willingness to pay

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LIST OF ABBREVIATIONS

CC	–	Climate Change
CH_4	–	Methane
CO_2	–	Carbon Dioxide
CORSIA	–	Carbon Offsetting and Reduction Scheme for Aviation
EU	–	European Union
EU ETS	–	European Union Emission Trading Scheme
GHG	–	Greenhouse Gas Emissions
IATA	–	International Transport Association
ICAO	–	International Civil Aviation Organization
IPCC	–	Intergovernmental Panel on Climate Change
NEP	–	New Ecological Paradigm
NGO	–	Non-Governmental Organization
NO_x	–	Nitrous Oxides
O_3	–	Ozone
SO_x	–	Sulphur Oxides
SQ	–	Search Query
SQLR	–	Systematic Quantitative Literature Review
VCO	–	Voluntary Carbon Offset
WTP	–	Willingness to Pay

1 INTRODUCTION

The corona-virus pandemic has impacted the aviation sector severely, with unpredictable consequences for the future of the industry, air travel and transport in general. Yet, it is still important to assess trends and developments in the industry up to that point. Not only to observe if companies and consumers will resume to previous behavior and trends continue to grow, but also to understand this crisis as a chance to (re-)set policies as well as strategic goals and implement changes to steer the industry towards a more sustainable future.

The Intergovernmental Panel on Climate Change (IPCC) has made it clear that man-made climate change is real, and the consequences for humans and the natural environment are severe (IPCC, 2014). The Fifth Assessment Report (AR5) also addresses the impact of transport sector emissions, which had a share of 14% of total global greenhouse gas (GHG) emissions in 2010. The urgency of the situation was further underlined by the Paris Climate Agreement, which has been a major breakthrough in international climate change policy and emphasized the need for immediate and effective climate action (UNFCCC, 2015). As for the aviation industry, the International Civil Aviation Organization (ICAO) as a specialized agency of the United Nations estimates that emissions could increase between 220% and 380% based on their 2015 values until 2050 depending on the scenario. It is therefore of high importance to act on this issue to mitigate the impacts aviation has on the climate. The measures proposed by the ICAO include operational improvements and technological solutions such as fleet renewal with more efficient aircrafts and engines, the use of sustainable, synthetic fuels and offsetting carbon emission with the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) (ICAO, 2020). Since the measures proposed by the industry cannot counteract the constant increase in demand for air travel (Tyers, 2018) which reached a new record growth in 2019 and totaling in 4.3 billion passengers (ICAO, 2020), additional measures have to be taken into consideration. One instrument in this regard are voluntary carbon offsets (VCOs), purchased by passengers themselves.

These have become more popular in recent years, with their demand increasing from 0.3 million tons in 2008 to 42.8 million tons in 2018. This has been credited by some researchers in part to the growing environmental movements such as the “Fridays for Future” protests (Bösehans, Bolderdijk, & Wan, 2020). Offset providers specified in carbon emission offsets related to aviation, such as atmosfair (recognized by Gössling et al., 2007 for its credibility and using scientifically sound and holistic methods) are reporting an increasing interest in their services and gain in financial capital, with atmosfair’s revenues increasing by 12 million Euros to a total of 22 million from 2018 to 2019 (atmosfair gGmbH, 2020b). Despite the recent demand increase in VCOs, earlier studies have found consistently low adoption rates amongst air passengers (Araghi, Kroesen, Molin, & van Wee, 2016; McLennan, Becken, Battye, & So, 2014), especially in the Asian markets (McKercher, Prideaux, Cheung, & Law, 2010; Shaari, Abdul-Rahim, &

Afandi, 2020). Higham, Ellis, and Maclaurin (2019) argued that climate change and the individual's contribution to it are difficult to accurately evaluate for consumer, so it therefore does rarely feature in the decision-making process for an individual's action. Furthermore, they conclude that air travel is a social convention which requires policy-led coordination for transition. This leads to the unfortunate situation were the most effective measure to reduce climate impacts of aviation - a reduction in demand, is unlikely to occur when responsibility is shifted to individual consumers (Higham et al., 2019).

On a global perspective, reports on the overall voluntary carbon offset market show no constant increase over the years in general, and the market share of voluntary offsets is still low compared to the mandatory compliance carbon market (Hamrick & Gallant, 2017). The report by Hamrick and Gallant (2017) notes that these fluctuant values are in part due to the transfer of voluntary contributions to the mandatory market, once a proper market mechanism such as a carbon price or tax is in place. Since the aviation industry is a global market with global competition, carbon taxes which are introduced on a national level are often opposed on the political stage (Choi, 2015). Furthermore, the industry considers such taxes as a hindering factor and a competitive disadvantage with little benefits compared to the schemes already in place. Namely CORSIA on international level and others on multinational level, e.g. the EU-Emission trading scheme EU-ETS (IATA, 2020).

On the other hand, these schemes are frequently criticized for major loopholes and a narrow scope. Whereas the EU provides 80% of the emission certificates to the aviation industry free of charge, the CORSIA scheme only applies to international flights between participating countries, with a voluntary participation up until 2026, and does not include national flights at all (Denstadli & Veisten, 2020; Hardisty, Beall, Lubowski, Petsonk, & Romero-Canyas, 2019).

Taking a look at the aspect of environment in the aviation sector from a research perspective, a previous literature review on air transport and tourism carried out by Spasojevic, Lohmann, and Scott (2018) using the same methodology as this thesis, identified carbon offsets as one area of growing interest in the research community. Spasojevic et al. (2018) could, however, only identify 37 papers which linked environmental aspects to aviation and tourism in general for the timespan from 2000 to 2014, with 12 papers originating from just 2 authors (Stefan Gössling & Paul Peeters). When assessing the awareness on carbon offsets amongst airline passengers, Gössling and other researchers in later studies frequently pointed out the low levels of awareness and participation in offset schemes amongst consumers (Gössling, Haglund, Kallgren, Revahl, & Hultman, 2009; Higham, Cohen, Cavaliere, Reis, & Finkler, 2016; Lu & Wang, 2018).

Since the willingness to pay and environmental knowledge of the travelers are assessed by carrying out questionnaires and interviews, the research results are in some ways limited. This refers to limitations in a geographical context, e.g. papers which study air travelers in Sweden (Gössling et al., 2009), Hong Kong (McKercher et al., 2010), or the Netherlands (Brouwer, Brander, & van Beukering, 2008) or a focus on specific socio-demographic groups, e.g. young frequent trav-

elers (MacKerron, Egerton, Gaskell, Parpia, & Mourato, 2009) or university students and staff (Choi & Ritchie, 2014). To the best knowledge of the author, no study so far has presented a holistic international perspective on the effects of environmental knowledge on passenger's WTP for voluntary carbon offsets.

This thesis is using a systematic quantitative literature review (SQLR) following the methodology developed by Pickering and Byrne (2014) to reveal the overarching connections between environmental knowledge and the willingness to pay of air passengers for voluntarily offsetting the carbon emissions they generate. According to Pickering and Byrne (2014), this method is suitable for young researchers to familiarize themselves with a research field and produce papers which are reproducible and not influenced by prior assumptions, so therefore less susceptible to bias. This method is in between the narrative review, which requires expertise in the field that younger researchers do not possess, and the systematic literature review in the context of a full meta-analysis which requires extensive resources in comparison.

Aside from using the SQLR to present the current state of research and identify gaps, a network analysis based on an incidence matrix is used to connect environmental knowledge to the influencing factors of the WTP for VCOs. Therewith, this study aims at providing insights on the following research questions:

- How do researchers define environmental knowledge and which aspects do they cover?
- How does the environmental knowledge of the passengers effect their willingness to pay, and which specific factors were supporting or hindering?

Additionally, it is tested whether or not the varying levels of the voluntary carbon market shown by Hamrick and Gallant (2017) also translate to the WTP of passengers, the stated WTP of study participants over the years is tested. Lastly, it is tested if there is a difference in the WTP amongst study participants who received information on environmental aspects, such as the impacts of their actions and the concept of carbon offsets by the researchers during the study, compared to those who were not informed.

2 THEORETICAL FRAMEWORK

2.1 Environmental Impacts of the Aviation Industry

The carbon dioxide ($CO_{2)}$ emission of the aviation industry account for about 2.5% of the total emissions produced in 2018 Although this number seems low, it should be noted that this is just one single industry with only 26,307 individual commercial aircrafts in operation (Cooper, Smiley, Porter, & Precourt, 2018) producing 564.612 Mt CO_2 in 2018. This resembles an increase in carbon emissions of 118% compared to 1990 (Crippa et al., 2019). A mere look at the emitted CO_2, however, does not paint a proper picture of the industry's impact on climate change. Aircraft engine emission are causing a short-term increase of ozone (O_3) as well as long-term ozone depletion in combination with a decrease in methane (CH_4). Additionally, emitting water vapor in the form of contrails as well as sulfur and nitrogen oxides emissions (Ritchie, 2020). The actual impact on the climate is therefore more severe than just its contribution of CO_2. Due to radiative forcing, the overall impact of aviation GHG emission accounts for about 3.5% of global warming (Ritchie, 2020). These emissions do not only impact climate change but also do have direct impacts on air quality and effect human health, especially in urban areas close to airports with economic importance or tourist hotspots. This has been assessed by Bo et al. (2019), who found the nitrous oxide as the most dominant in terms of air pollution and environmental impact, but also included particulate matter, sulfur dioxide and carbon monoxides as emissions affecting the local air quality.

Aside from the overall impact of the industry on climate, air travel also heavily increases the personal CO_2 footprint of consumers. As an example: a roundtrip economy flight for a vacation in Bali (Indonesia) from the German airport of Hamburg (IATA code HAM) to the Ngurah Rai airport in Bali (IATA code DPS) accounts for about 7 tons of CO_2 (based on the calculation by atmosfair, see atmosfair gGmbH, 2020a). A suitable comparison to highlight the high impact of an individual's action is the circumstance that this number is quite close to the average emissions of an entire year for a German citizen, which was about 9 tons per capita in 2018 (Crippa et al., 2019).

In terms of reducing those impacts, it can be observed that constant technological improvements had led to an increase in efficiency, best visible if calculated in CO_2 per passenger kilometer (referring to the total amount of CO_2 produced in kilogram per each kilometer of flight divided by passengers). This factor has become about 80 more efficient compared to the 1960s (ICAO, 2020). The ICAO 2019 Environmental Report further states the increase in aircraft size and passenger seats as well as engine and fuel optimizations as a major role in this achievement.

However, all these improvements cannot counteract the steep increase in passenger numbers and demand for air travel (Higham et al., 2019; Tyers, 2018),

which has been a long known problem in regards to the growing impact of aviation (IPCC, 1999). Additionally, it is doubtful if promised technological advances will be able to live up to the expectation, as past experiences show (Peeters, Higham, Kutzner, Cohen, & Gössling, 2016).

Even major historical events with heavy impacts on the industry and air travel in general, like the 9/11 terror attacks and the following debate on terrorism which lead to massive increases in security measures, did not slow down the growing demand in the long term. The same applies to the financial crisis of 2008/2009, with heavy impacts on the global economy and therewith the disposable income of households (The World Bank, 2020). These effects can be seen in Figure 1, which shows only temporary, small decreases following the prior mentioned events and the previously mentioned record increase in passengers in recent years (ICAO, 2020).

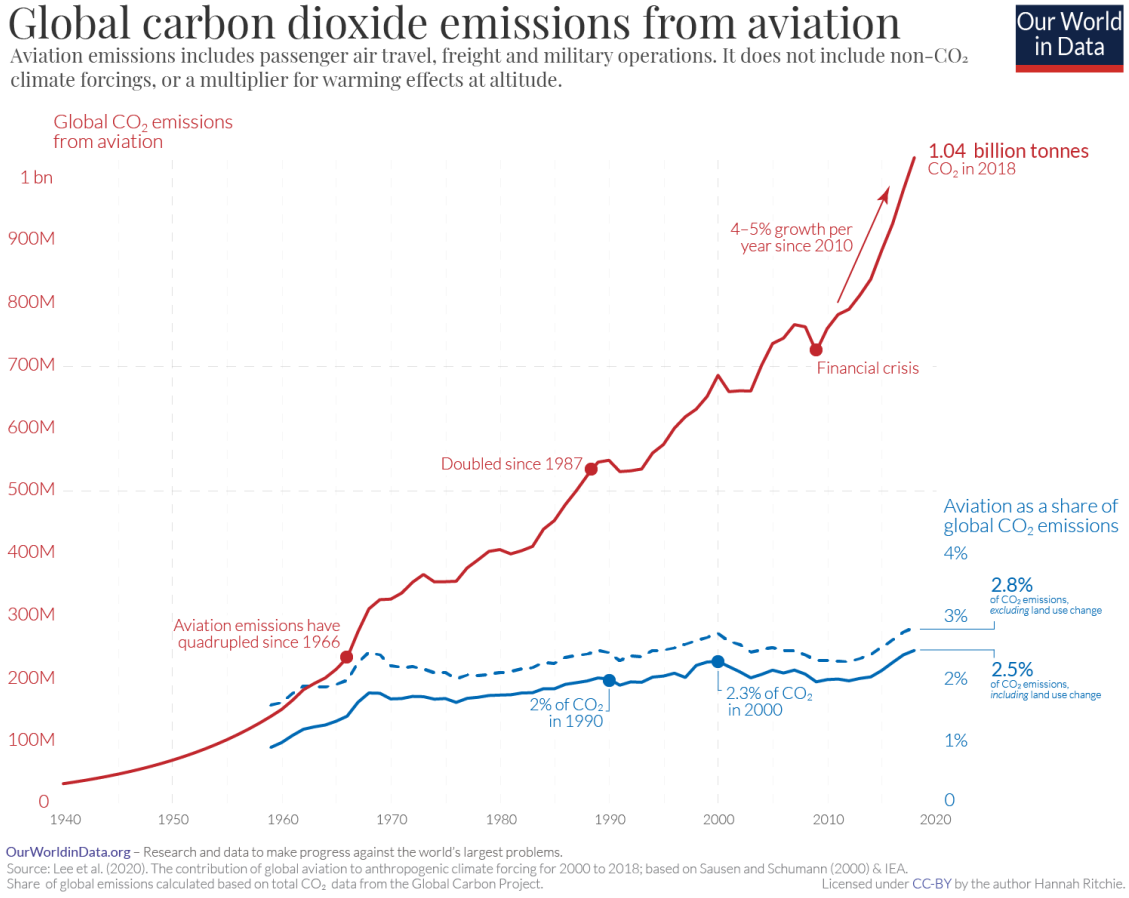

Figure 1: Global carbon dioxide emissions from aviation (The World Bank, 2020)

Since this problem is well known, national, multinational and international policy makers started to include the aviation sector into existing policies or implementing new regulations to cope with the problem. The IPCC already highlighted the role of aviation on climate change in their 1999 special report (IPCC, 1999), and is still raising awareness on the mitigation potential in a shift from aviation to other modes of transportation in the AR5 report (IPCC, 2014).

The strategic goals of the ICAO to reduce emissions are centered around a carbon neutral growth from 2020 onwards. The proposed "*basket of measures*" includes several means of fighting the growing impact of the industry, namely improvements in engine technology and fleet renewal, improvements in operations and so called green- or synthetic fuels (ICAO, 2020, p. 111). One major aspect of the overall strategy is the Carbon Offset and Reductions Scheme for Aviation (CORSIA), which is aiming at counteracting the emissions which cannot be avoided by technological progress and optimizations in operations and management.

The possibility of emission reduction by a decrease in passengers is not part of this "*basked of measures*" by the ICAOs and therefore not part of their environmental strategy (ICAO, 2020, p. 111). The reason for this is for once because of the previously mentioned strong increase in demand, but also because a strategy of controlled decrease in passengers is in contrary to the general business model of an airline.

2.2 Carbon offset mechanisms

The term "carbon offset" refers to an amount of carbon dioxide equivalent which has not been emitted to the atmosphere by reduction measure or sequestration efforts from projects on the ground (Hamrick & Gallant, 2017). Carbon offsets are provided either by independent commercial offset providers or NGOs, which offer varying ways of offsetting emissions with varying allocation methods and prices (Gössling et al., 2007). Seller and buyer of carbon offsets can either meet directly by purchases from providers or donations to NGOs, or on a set up market which provides so called carbon credits, connected to the amount of CO_2 to be offset and acting as an intermediary (Hamrick & Gallant, 2017).

Carbon emissions can be offset in different ways. The most distinct separation can be made between avoidance and sequestration. Whereas offset projects surrounding renewable energy are replacing fossil fuel use and therefore offsetting the emitted CO_2, plantations, forest protection and reforestation provide carbon sequestration through growth (Becken & Mackey, 2017).

Polonsky, Garma, and Landreth Grau (2011) grouped these into four different categories of offset activities, namely:

- biological sequestration by preserving or planting trees to absorb carbon from the atmosphere
- developing renewable energy projects which produce energy without emitting carbon dioxide
- increase energy efficiency measures to reduce emissions
- and reduction of non-CO_2 GHG from specific sources

The schematic process from developing an offset project to selling/buying it up to so called retirement, meaning the end of commercially selling a carbon credit, can be seen in Figure 2. Crucial in this process are the validation of the proposed

offset by the project developers by a third party authority and the successive verification by another audit process after successful implementation and monitoring of the project (Hamrick & Gallant, 2017).

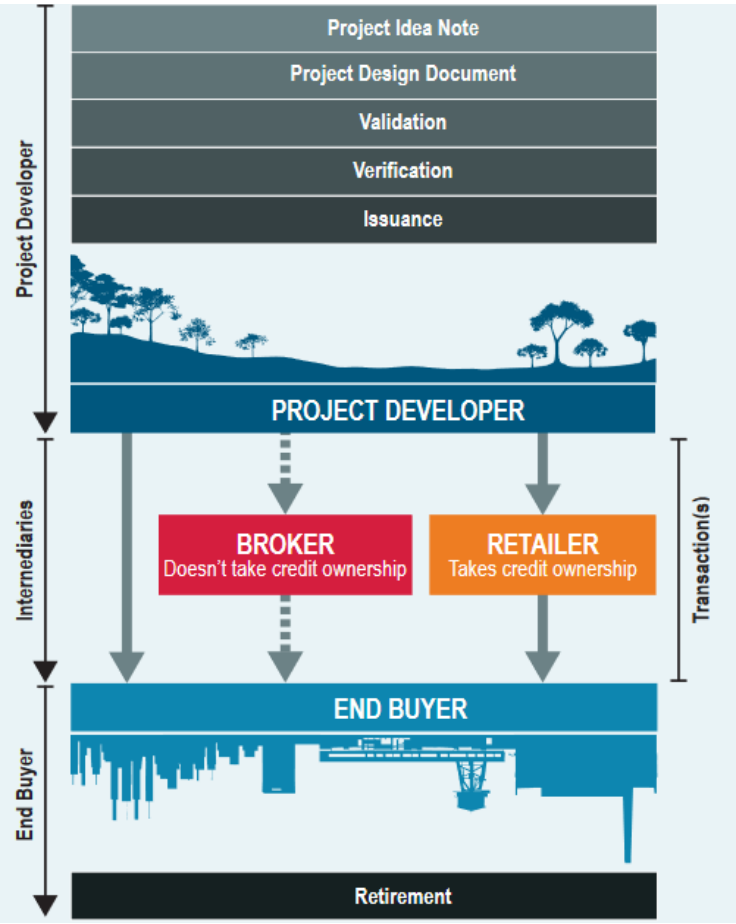

Figure 2: The Offset Cycle, from Project Development to Retirement (Hamrick & Gallant, 2017)

Forest based offset projects (re-/afforestation, plantations and protection) are being discussed controversially to some extent, most commonly due to uncertainties surrounding the effects of sequestration by forests and carbon accumulation, which are still disputed in the research community (Cook-Patton et al., 2020).

Yet, different project types also provide additional co-benefits in multiple dimensions, such as biodiversity conservation by forest protection, economic benefits for communities and improvements in human health and development (Babakhani, Ritchie, & Dolnicar, 2017; MacKerron et al., 2009). Aside from direct benefits to projects participants, indirect co-benefits like increased media coverage to raise awareness on climate change (MacKerron et al., 2009). Furthermore, MacKerron et al. (2009) also argue that increased engagement in carbon offsetting demonstrates support for pro-environmental policies to policy-makers. Lastly, the authors also referring to the potential of a voluntary offset market for investments in high-risk, high-reward projects with greater impacts than conventional investments.

However, offsets in general are often seen as a second-best option compared to simply avoiding emissions in the first place, therefore just reducing the

feeling of guilt in consumers without steering them towards pro-environmental behavior (Bösehans et al., 2020; Higham, Cohen, & Cavaliere, 2014). This is especially relevant in light of the hypermobility in air travel amongst consumers (Shaw & Thomas, 2006). Additionally, the offset market has frequently been criticized for various issues, most notably a lack of trust and transparency while consumers questioning the connection between paying money and saving the environment. (Choi & Ritchie, 2014; Higham & Cohen, 2011; Higham, Cohen et al., 2016). These issues have been prevalent since the emerging of this market, as Gössling et al. (2007) pointed out. The authors found substantial differences across organizations, not only in terms of prices, but also regarding emission calculations and evaluation criteria, negatively affecting the credibility of the market. These shortcomings seem not to be overcome yet.

2.3 CORSIA and the EU Emission Trading Scheme

As for the aviation industry, the most important offset scheme in place is the previously mentioned CORSIA, which became effective in 2016 with a binding participation for all member states from 2027 and voluntary participation up to that date (ICAO, 2020). This mechanism was installed since the aviation sector, due to its characteristics and international operations, was not included in the nationally determined contributions of the signing countries of the Paris Agreement (Higham et al., 2019). Additionally, the industry demanded an internationally harmonized framework for the reduction of its environmental impact, in order to keep international competition open and avoid a so called "*patchwork*" of national regulations for airlines (ICAO, 2020, p. 115). Although the CORSIA scheme, originating from the ICAO Assembly Resolution A40-19 is the first industry-wide global carbon offsetting scheme for aviation and marks an important step towards more sustainability in the air and setting specific criteria for carbon offset unit's integrity (ICAO, 2020), the mechanism has been frequently criticized (Denstadli & Veisten, 2020; Hedley, Rock, & Zaman, 2016; Higham et al., 2019; Maertens, Grimme, Scheelhaase, & Jung, 2019).

Hedley et al. (2016) summarized the criticism into three distinct aspect. First, the exemptions. CORSIA only applies for airlines which emit more than 10,000 tons of CO_2 per year and does not take small aircrafts below 5.7 tons max. take-off mass into consideration. Additionally, all flights from or to the so called Least Developed Countries, Small Island Developing States, and Landlocked Developing Countries as well as special category flights are exempt. Although this might support economic growth through tourism in the countries to which this definition applies, some researchers like Peeters and Eijgelaar (2014) found the possible impacts of travel restrictions on the local economy to be neutral overall. Another critical aspect in terms of exemption is the circumstance that only CO_2 emission are covered. Other GHGs, such as NO_x and SO_x, are not included (ICAO, 2020). Most important however is the exemption of all domestic flights. Therefore, only about 40% of global aviation activity are actually covered by this scheme.

Second, the level of ambition has been criticized by Hedley et al. (2016) for being relatively low. Although the pilot phase of the CORSIA scheme came into effect in 2016, the set baseline on which the carbon neutral growth, the key aspect of the ICAOs environmental strategy (ICAO, 2020), is based upon, is 2020. The aspect of carbon neutral growth also highlights another shortcoming: absolute reductions in carbon emissions are not intended (Becken & Mackey, 2017).

Third, due to the numerous exemptions, there is a risk of loopholes to be exploited by airlines, causing a distortion in behavior. In practice, this could mean a shift of routes to exempt countries in close proximity, or short haul international flights to neighboring countries to be directed to close-by national airports.

On top of these shortcomings, it should also be noticed that participation will be on a voluntary basis during the pilot- and first phase of the implementation, up to 2027, with unclear reasoning behind this decision (Higham et al., 2019). The dreaded national patchwork might be unavoidable, as several nations acknowledged the role of aviation as a major contributor to climate change. Airline emissions are therefore already subject to various national and multinational regulations. A few examples of these are taxes directly on carbon emission and a CO_2 based vehicle tax in Sweden (Sonnenschein & Mundaca, 2019), air traffic specific surcharges as for example in France (IATA, 2020) and the EU Emission Trading Scheme (EU ETS) (European Commission, 2020). The latter covering about 40% of the EUs GHG emissions and aims at achieving the strategic goal of a net reduction of 55% EU-wide until the year 2030 (European Commission, 2020).

In contrast to the CORSIA scheme, the EU ETS works with a cap-and-trade system, allowing only a set amount of carbon emissions to be emitted. The level of the cap is reduced constantly by the EU, therefore putting pressure on industries to reduce their GHG emissions. This mechanism also ensures an increasing demand and proper prices for carbon credits (European Commission, 2020). Although it has been a point of critique for the CORSIA scheme to not include a cap on carbon emissions (Hedley et al., 2016), it should be noted that this is the intended strategy of the ICAO and the purpose of the CORSIA scheme, which aims at carbon neutral growth and provide a proper supply in aviation adequate to the growing demand (ICAO, 2020).

Critics of the EU ETS scheme point out that the aviation industry receives 80% of their CO_2 certificates free of charge, which negates the intended effect to steer industries towards low-carbon solutions and reduction (Denstadli & Veisten, 2020). On the initial incorporation of the international aviation industry in 2012, it was intended to include all flights arriving or departing within the EUs member states into the EU ETS, yet the scope was changed to only include flights within the European Economic Area to ease negotiations with ICAO and respond to strong international opposition (Scheelhaase, Maertens, Grimme, & Jung, 2018). The industry might however face an increase in costs due to new ambitions of the EU Commission to achieve a 55% reduction in GHG emissions instead of the previously intended 40% until 2030 compared to the 1990 baseline (Kazooba, 2020). This would be possible by reducing the amount of certificates

issued free of charge and broadening the scope for the aviation industry to include all flights from and to the EU, as intended back in 2012 (Kazooba, 2020; Scheelhaase et al., 2018).

Aside from these offset schemes and regulations, several airlines are working independently in cooperation with offset providers to counteract their respective impact on the environment on a voluntary basis, as Becken and Mackey (2017) found. Becken and Mackey (2017) identified 44 airlines out of 139 which were actively involved in offsetting activities which were, however, in part untransparent and/or poorly communicated to consumers. Their proposed best practice for airlines consisted of a clear wording in communication, providing information to consumers and the use of credible, third-party audited projects with clear methodology for calculating reductions. Communicating voluntary actions might however not be done in a proper manner, since the studies by Babakhani et al. (2017), Zhang, Ritchie, Mair, and Driml (2019b) and Higham, Cohen et al. (2016) indicated shortcoming in the way airlines communicate and provide information to passengers as well as a lack of transparency in regards to carbon offsets. Zhang et al. (2019b) furthermore investigated the credibility of airlines and argue that trustworthiness positively influences purchasing decisions. Intransparent provision of information and poor communication damage the source credibility, therewith becoming a hindering factor (Zhang et al., 2019b). This further underlines the crucial role of communication in the relation between airlines and pro-environmental passengers.

2.4 Willingness to Pay for Pro-Environmental Goods

The "Willingness to Pay" (WTP), a concept which dates back to 1902 (Davenport, 1902), is commonly defined as the "*[…] maximum price a buyer accepts to pay for a given number of goods or services*." and provides valuable insights not only on price elasticities but can also be linked to influences in decision making (Le Gall-Ely, 2009, p. 93).

Studies surrounding environmental aspects of consumerism within the research on the aviation industry have brought forward various aspects which can be considered by pro-environmental consumers, like carbon neutral transfer to the airport, organic on-board meals, on-board purchase of sustainable products and of course carbon offsets (Hinnen, Hille, & Wittmer, 2017). Additionally, there is also WTP for aspects of the aviation's infrastructure like environmentally friendly airports or the increased use of biofuels (Rice, Ragbir, Rice, & Barcia, 2020).

Companies can decide on how to offer these products to their customers, with the most common practice being a standard air fee with optional purchases of supplementary services or goods (Hinnen et al., 2017). Bösehans et al. (2020), however, suggest that in case of carbon offsets an incorporate fee with the air fare would be a more suitable option than selling it as an additional product, therewith contradicting the industry practice. Although possibly increasing adoption,

this could also result in lower WTP, as Sonnenschein and Mundaca (2019) found that WTP is also dependent on the payment vehicle. Their study found the WTP for a climate surcharge on long-haul flights to be almost twice as high as the WTP for carbon offsets with 36 EUR compared to 14 EUR respectively (Sonnenschein & Mundaca, 2019).

The argument for an incorporation is in part due to the circumstance that offsets as a product are problematic because they do not offer co-benefits to passengers compared to other pro-environmental products like better food quality in organic food, or financial benefits from energy saving (Hinnen et al., 2017). A comparison to other voluntary actions with no direct benefits like boycotting an environmentally unfriendly company or buying green electricity is therefore more suitable according to Hinnen et al. (2017), who argue that purchasing green products in aviation triggers a mental self-justification process which increases mental activity related to abstract values and attitudes in a similar way.

WTP for environmental goods in general and offsets in particular have found a wide range of WTP across studies, reaching from a couple of Euros to several hundred per ton of CO_2, depending on socio-economic factors, local or regional circumstances, elicitation format and payment vehicle (Sonnenschein & Mundaca, 2019). Other dimensions of WTP previously assessed include the price per flight (Babakhani et al., 2017), price per 100km of flight distance (Brouwer et al., 2008) or share of ticket price (Akter, Brouwer, Brander, & van Beukering, 2009). It should be noted in this regard that the WTP consistently appears to be positive for pro-environmental goods and services in the aviation industry (Sonnenschein & Mundaca, 2019).

2.5 Inconsistencies and Limitations of Prior Research

The preliminary review for this study revealed contradicting statements in terms of influences on the willingness to pay, indicating the need for secondary research in form of a literature review to reveal on a broader scope which tendencies could labelled as a status quo or standard while others are outliers. This is referring for example to the study of Mair (2011), who examined if older, female consumers were more likely to engage in pro-environmental behavior as previous research suggested, but could not confirm this hypothesis. Other studies with a focus on aviation, however, confirmed this assumption. Like Rice et al. (2020) who found females to be more likely to pay an additional fee for a flight which a more fuel-efficient airplane.

This might be due to cultural differences and is therefore connected to a common limitation in studies surrounding carbon offsets in the aviation industry, which is the regional context. Most studies were found to be based on survey or interview data, which could only lead to conclusions applicable to the researched group and their cultural and market background.

Some studies which collected empirical data by surveys at airports assessed and acknowledge the differences in international travelers. However, since the

vast majority of travelers participating in the surveys were residents of the country the survey was conducted in, the sample sizes for international passengers were rather low. Brouwer et al. (2008) who conducted their survey at the Amsterdam Schipol airport in the Netherlands are one example in this regard. The largest group in Brouwer's study, which had about 400 participants, were Dutch citizens with a share of 27% in total. Although 20% of study participants were Asian, these consisted of 7 different nations and therefore limiting the insights for each country when compared to the Dutch sample. Grouping survey participants into broad categories such as "Asian" or "European" due to low sample sizes obscures differences in cultural backgrounds, since single continents do not share a common culture. Scholars who used online survey pools, like Choi, Ritchie, and Fielding (2016) and Hardisty et al. (2019) often targeted only the nationals of the respective country of interest. This is however not representing the air travelers within a certain country due to international business and holiday travel (see Brouwer et al. (2008) which referred to the nationality of travelers arriving and departing at Schipol airport).

Other studies focused their research on specific socio-demographic groups of consumers. While MacKerron et al. (2009) researched young adults in the United Kingdom who were frequent flyers, Fatihah and Rahim (2017) only included government employees with high mobility by frequent business travels. Conclusions for the general public or market are therefore limited. These limitations could be overcome by a literature review with no limiting criterion for the geographical or socio-demographical setting of a study.

3 METHODS

A preliminary literature review was carried out by using the broad terms "carbon" AND "offset" AND "aviation" for a search on Google Scholar to identify general topics relevant in this area of research. On the first search through the database, 32 scientific journal articles related to the overarching theme were identified and the keywords of relevant literature were analyzed.

3.1 Selection of Method

Conducting a literature review can be done in various, distinct ways with own methodology. For once, researchers can conduct a traditional narrative review (see Green, Johnson, & Adams, 2006) which requires a certain level of expertise in the field and is most suitable for experienced researchers to provide updates on the current state of research within their field. Another way to get expert evaluation on a topic are weighted or ranked reviews, which approach the literature more systematic and enable some statistical analysis (Petticrew & Roberts, 2006). Lastly, literature can be reviewed in a systematic, quantitative manner by a process which aims at ensuring objectivity as well as replicability (Pickering, Grignon, Steven, Guitart, & Byrne, 2015). The latter does not require expertise in the field and is therefore suitable for early career researchers and PhD students entering a scientific field.

Pickering and Byrne (2014) describe their method as a systematic, quantitative literature review (SQLR), which is in between a traditional narrative literature review and a meta-analysis. The method allows for a systematic approach without expertise in the field of interest and is feasible to do without the resources needed for a meta-analysis, which is usually done by teams of researchers with diverse expertise over a prolonged period of time (Petticrew & Roberts, 2006). Additionally, some topics are not covered well enough to provide sufficient data to carry out a proper meta-analysis. Pickering and Byrne (2014) also argue that their method is beneficial for addressing concerns about bias through the systematic and replicable approach, although not completely eliminating them.

The process of writing reviews with the SQLR method is divided into 15 distinct steps, as can be seen in Figure 3. The first phase (step 1 to 5) supports the method user in approaching a topic systematically, from its definition and the formulation of research questions to the search for literature with proper keywords in credible databases. In a second phase (step 6 to 10) guidance is provided on the construction of a database containing and quantifying data assessed from the literature. Lastly, in step 11 to 15, the method provides support for structuring and writing the review (Pickering & Byrne, 2014).

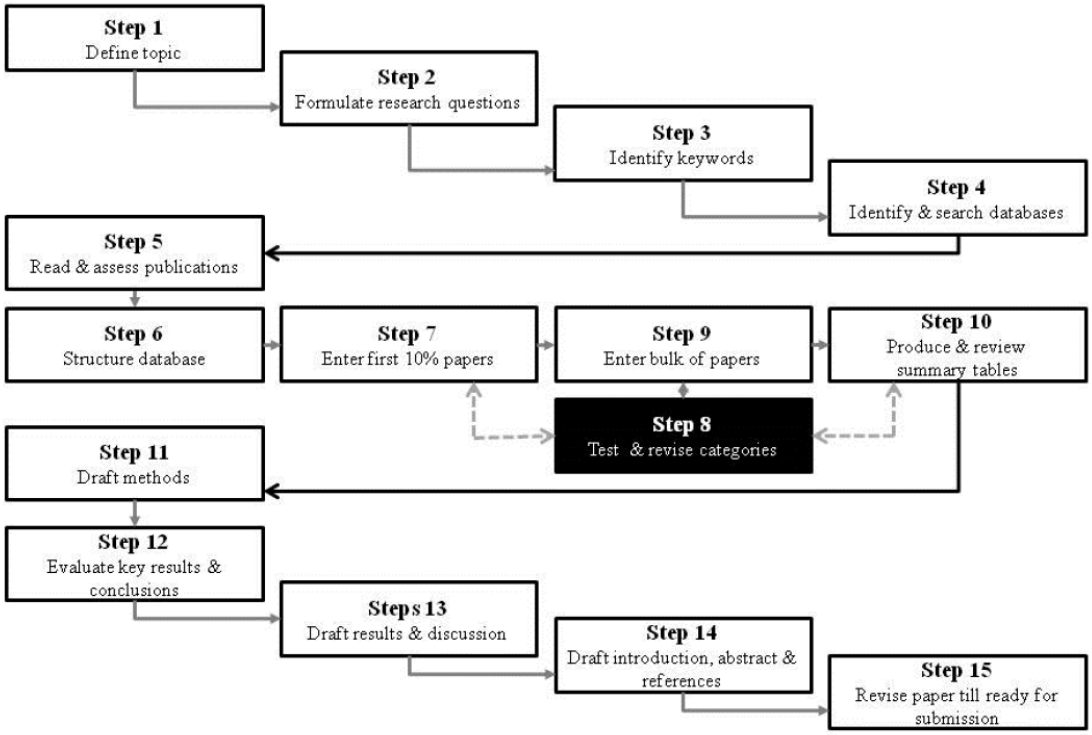

Figure 3: Fifteen stages in undertaking systematic quantitative literature reviews (Pickering & Byrne, 2014)

The SQLR suits the level of knowledge of the author, is feasible to carry out with the given resources and expected to provide adequate results for identifying gaps in the literature and answer the research questions. Therefore, this method was chosen.

3.2 Keyword Identification and Search Design

As recommended by Pickering and Byrne (2014), only articles in peer reviewed journals are included in the database to match the criterion that "*the paper must be an original research paper*" (Pickering & Byrne, 2014, p. 543). A peer-reviewed database also allowed for efficient background checks on the credibility of papers, for which the SCImago CiteScore™ was used. Studies not included in this were checked individually by carrying out background checks on the author's publishing history. Several databases of publishers were included to search specifically within their respective journals. The publisher-based databases selected were Emerald Insight (Emerald Publishing) SAGE (SAGE Publishing) and Science Direct (Elsevier). Additionally, larger interdisciplinary databases with a strong reputation were included. This refers to Web of Science, Scopus and ProQuest. This mix ensured a comprehensive coverage of sources as well as allowing for cross checks amongst the databases (Pickering & Byrne, 2014). The search procedure followed the Preferred Reporting Items for Systematic Reviews

(PRISMA) statement by Moher, Liberati, Tetzlaff, and Altman (2009). The statement provides evidence-based guidelines and best-practice recommendations to improve reporting on systematic reviews and meta-analyses.

To gather all relevant sources related to the topic, the following search terms were selected and alternated. The synonyms from the wording of the title were identified by using the Merriam-Webster Thesaurus (Merriam-Webster, 2020), choosing logical words in the context of the topic. This led to the preliminary search query:

“carbon” OR “CO2” OR “emissions” OR “greenhouse gas emissions” OR “carbon dioxide”
AND
“Offset” OR “Offsetting” OR “compensation”
AND
“aviation” OR “air traffic” OR “air travel” OR “air transport” OR “airlines” OR “flight”

These search terms by themselves had proven to create a high amount of irrelevant results and were therefore further refined by adding different terms on top of this “body” to search for specific papers within the results. To assess and compare the results easier, the search queries were split up thematically and adapted over time.

Search Query 1: "Willingness to pay" (“carbon” OR “CO2” OR "greenhouse gas emissions") (offset* OR “compensation”) (“aviation” OR "air travel" OR "air transport" OR "air traffic" OR “flight” OR “airline”)

Search Query 2: “Environmental knowledge” (“carbon” OR “CO2” OR "greenhouse gas emissions") (offset* OR “compensation”) (“aviation” OR "air travel" OR "air transport" OR "air traffic" OR “flight” OR “airline”)

After the preliminary review, the first database search was carried out with the search queries (SQ) 1 and 2 throughout all mentioned databases. The fields relevant for the search were “keywords”, “abstract” and “title” of the publication. Aside from the filter option to only show peer-reviewed journal articles, there were no restrictions in terms of scientific field, date of publishing or other. Identified results were then transferred to RefWorks for further assessment and the removal of duplicates. For this step, the tools RefWorks provided were used as well as a manual check to ensure that no duplicates remained.

Emerald Insight was excluded after screening the results from SQ 1 & SQ2 since it did not provide any papers relevant for screening. Also, since Emerald Insight is lacking the option to export references to RefWorks, it created additional workload without an adequate outcome.

After the screening of the results from SQ1 and SQ2, the keywords of eligible papers were collected and analyzed to improve the coming search queries and

identify further papers as well as improving the quality of the search. Since especially the term “Environmental Knowledge” did not perform well and brought back little to no search results, it was switched with “environment*” to broaden the results. The ongoing keyword check additionally revealed various keywords related to environment aside environmental knowledge, e.g. environmental attitudes, -behavior, -policy and -value. Therefore, SQ 2 was changed and re-run. This insight was one of the intended benefits of splitting up the search terms into a fixed body and varying SQs, and would have been hard to identify in a general query designed as (“willingness to pay” OR “environmental knowledge” OR “voluntary” OR touris*) […]. The keyword “voluntary” appeared in a high frequency (11 times in 44 papers with 212 keywords total) and was therefore selected for the third search query. Additionally, some relevant papers were related to the field of tourism and tourist behavior (7 times mentioned), so “touris*” was chosen for SQ 4. Other frequent keywords like “Climate Change” were excluded, since the term has shown to be too general to identify papers of relevance. Another adoption of the search queries was the reduction of “greenhouse gas emissions” to “emissions”, because the term seemed to be too narrow and exclude papers which were using “emissions” as a synonym for greenhouse gas emissions.

Search Query 1 (adapted): “Willingness to pay” (“carbon” OR “CO2” OR " emissions") (offset* OR “compensation”) (“aviation” OR "air travel" OR "air transport" OR "air traffic" OR “flight” OR “airline”)

Search Query 2 (adapted): environmental* (“carbon” OR “CO2” OR "emissions") (offset* OR “compensation”) (“aviation” OR "air travel" OR "air transport" OR "air traffic" OR “flight” OR “airline”)

Search Query 3: “voluntary” (“carbon” OR “CO2” OR " emissions") (offset* OR “compensation”) (“aviation” OR "air travel" OR "air transport" OR "air traffic" OR “flight” OR “airline”)

Search Query 4: touris* (“carbon” OR “CO2” OR " emissions") (offset* OR “compensation”) (“aviation” OR "air travel" OR "air transport" OR “flight” OR “airline”)

SQ3 and SQ4 brought forward some additional papers, yet the frequency of duplicates increased constantly up to the level at which point there was no more value in carrying out more searches or constructing another SQ. The results for each search and database were recorded, which lead to the table displayed in Table 1.

Table 1: Articles retrieved by search query and database

	Web of Science	ScienceDirect	SagePub	Scopus	ProQuest	Emerald Insight	TOTAL
WTP (SQ1)	25	8	0	14	12	23	59
ENV (SQ2)	34	15	1	45	22	7	117
VOL (SQ3)	26	10	2	24	26	x	88
TOUR (SQ4)	21	2	1	20	13	x	57
TOTAL	106	35	4	103	73	x	321

To identify additional papers which could not have been identified through the database search, the references of included papers were checked for relevant references. In addition to this, the databases were used to identify papers which cited the included papers. Duplicate check, screening and full-text eligibility check were carried out for each paper separately, but consistent with the previous procedure.

3.3 Database Construction

A database was constructed by starting off with simple metrics and information on authors and journals, followed by the details on the study's research design and methods used as recommended by Pickering and Byrne (2014). Since almost all of the studies were using surveys or interviews, the next step was to create categories for the participants information assessed and the way it was collected. These included the survey design as well as the demographics and other information gathered. Influencing factors on the willingness to pay were identified and noted down in a combination of categories (demographics, behavior, attitudes, offset and airline) to assess the findings of the studies. By enlarging the aspects covered in those categories and providing a connection to their impact on the WTP by a simple "- / o / +" scale to show negative, neutral or positive relations, the findings of the papers are represented adequately. Bridging the pure participants information and the findings in form of the WTP influences are the aspects of environmental knowledge covered in the papers. Since there seemed to be a difference in the approaches by the authors on how or if information on environmental aspects were provided to study participants, a sub-category for this was installed. Finally, for those studies who showed concrete numbers and/or shares of people willing to pay and the amount of money they would be ready to spend, the category "Attitude-action relation" was added. Different colors were used in order to ease and speed up the orientation within the database. To get an understanding, Figure 4 shows the first section of the database up to column 96 or "CR" (504 columns in total) with the sections Research and Journal Data, Research Design and Approach, and Participant's Information Assessed.

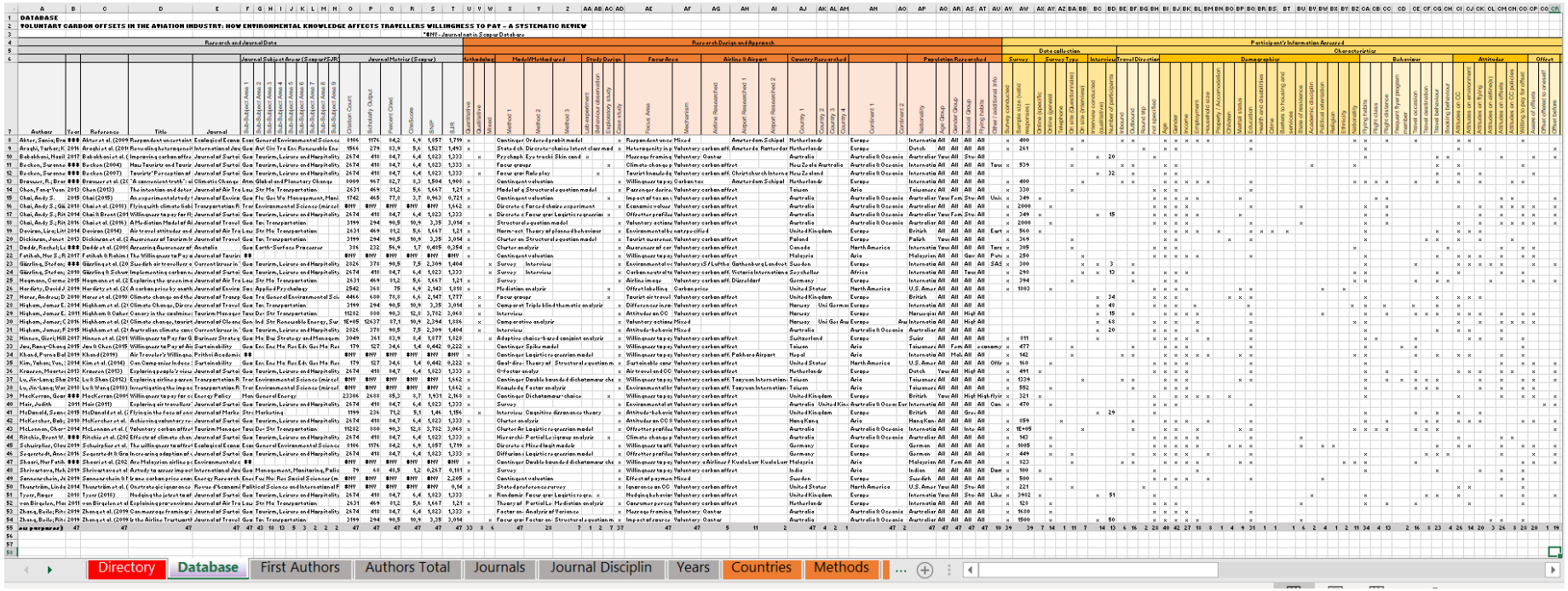

Figure 4: Section of the database created in Microsoft Excel

In order to harmonize the data and allow for overarching analysis, some assumptions and generalizations had to be made. Definitions in the demographics and behavior section for "lower" and "higher" behavior patterns or "younger" and "older" age followed the phrasing and definitions of the authors. Testing has shown that absolute values or shares of researched population (e.g. first, second and third quarter of range of age) were not feasible.

Factors included into the "Willingness to Pay – Influencing Factors" section were only those that were specifically stated by the researchers to have a positive, negative, or no significant effect on the WTP. Factors which were assessed in interviews and surveys but were not further used for analysis were not automatically assumed to be neutral and left blank in the database. Generalized columns such as "Environmental knowledge" as part of the information gathered from study participants were replaced by more precise descriptions, e.g. their attitude on CC, attitude on flying and attitude on offsets.

After entering the first share of papers, minor difficulties were noticed: Some studies, namely Brouwer et al. (2008) and Akter et al. (2009) as well as Choi (2015) and Choi and Ritchie (2014) are based on the same data due to publishing multiple papers out of one database. Even though this results in double entries within the "participants information" section, they were not excluded. Different focus areas on the same data can produce different perspectives and insight on the same data, which is of interest and value for the assessment of the environmental knowledge and the influences on willingness to pay. The information provided on the participants information was assessed for each paper separately and included in the analysis. After initial testing, it was evident that authors did mention different aspects of the databases and information they included. This led to different results, even if the database/survey used was the same. This resulted in different and relevant insight on the aspects the authors choose to cover for their respective study.

Whereas main categories were sufficient, and the overall structure of the database supported the information of the papers well, sub-categories were subject to constant change and adaption, mostly enlarging their content and adding in new aspects. One important addition was the sub-category "Mechanism" in the "Focus Area" section. After it became clear that a strict separation of studies who focused exclusively on voluntary carbon offsets from others would not be feasible and exclude papers with highly relevant content, this sub-category was added for clarification. Therewith, papers who included multiple mechanisms (including VCOs) or who studied the general willingness of travelers to pay for carbon offsets without specifying the precise mechanism could be included. The circumstance that those studies who focused on VCOs frequently referenced non-specific offset WTP studies and vice versa strengthened this decision and indicated the relevance and dependence for the overall results and conclusions.

When fixed amounts were stated, only financial aspects of the whole sample were considered, and not individual groups with a higher or lower average WTP (e.g. climate sceptics vs. concerned people or international vs. domestic flights). This would not allow an even comparison of the samples, and group definitions varied across studies and did not occur frequent enough to justify

separate columns. Demographic characteristics which shared a common meaning, like occupation and employment status were grouped together because these terms were used interchangeable across the studies.

3.4 Network Analysis Construction

In order to analyze the relations between environmental knowledge and its effect on the WTP, a network analysis was carried out using the statistics software R. The constructed network was based on an edge list, generated out of an incidence matrix connecting each aspect of environmental knowledge to the influencing factors they were related to thematically. The networkD3 package of R was used to generate an interactive network, allowing an easy assessment and understanding. An attempt at including weighted links based on the occurrences of aspects and influences within the studies was disregarded due to the limited programming skills of the author.

The following code was used to create the network plot:

```
library(igraph)

library(networkD3)

library(htmlwidgets)

edge <- read.csv2("Edgelist.csv")

simpleNetwork(edge, height=NULL, width=NULL, fontSize = 12, nodeColour =
"green", zoom=T)

p <- simpleNetwork(edge, height=NULL, width=NULL, fontSize = 12, nodeCol-
our = "green", zoom=T)

saveWidget(p, file=paste0( getwd(), "networkInteractive2.html"))
```

4 RESULTS

The identified papers were compiled into a database in Microsoft Excel for analyzing. In total, 504 columns containing information on research and journal data, research design and approach, participant's information, environmental knowledge, influencing factors on willingness to pay and the attitude-action relation were collected from the studies.

4.1 Study selection

After the process of identifying relevant literature, 332 papers were considered for screening. Of those, 189 records were screened. After removing 130 records, 59 were considered for a full-text eligibility, and 12 excluded afterwards, leaving 47 for the analysis. Figure 5 presents the detailed process of study selection according to the PRISMA guidelines (Moher et al., 2009).

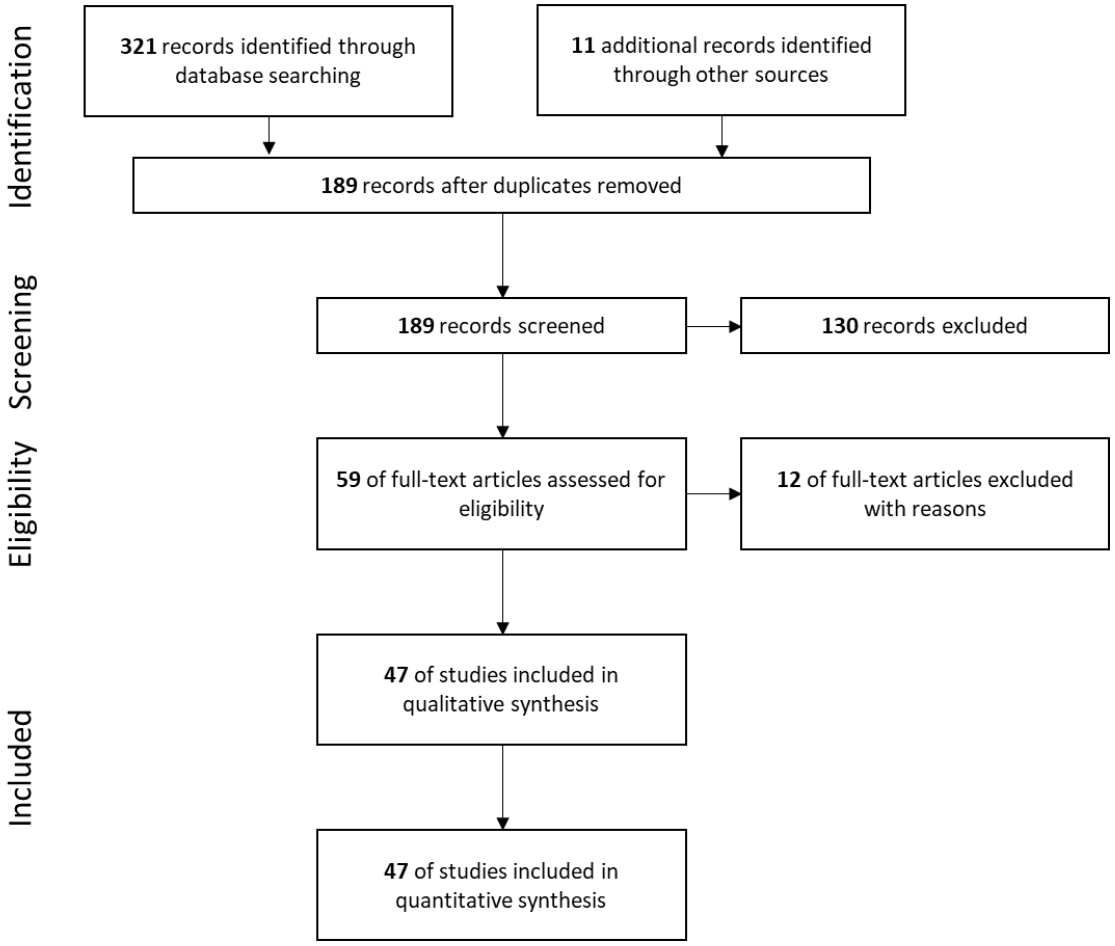

Figure 5: PRISMA flow-chart with number of studies at each stage of the process

Papers excluded during screening included different carbon offset schemes like the EU Emission Trading Scheme or CORSIA and other means of carbon reduction like green aviation fuel or technological improvements. Additionally, studies on the general impacts on aviation on climate change or the environment, offsetting behavior unrelated to air travel, and studies on travel behavior in an environmental context, but without the aspect of carbon offsets were excluded.

The reason for excluding papers after screening were a focus exclusively on non- voluntary carbon offsets in the form of carbon taxes or integrated carbon offsets, e.g. Denstadli and Veisten (2020) and Bösehans et al. (2020). There were also studies with a focus on other actors within this area like offsetting providers and the offsetting market, e.g. Gössling et al. (2007). Araghi, Kroesen, Molin, and van Wee (2014) was excluded since it used the same database as Araghi et al., 2016 and did not provide additional insights relevant to the research question, therefore producing a full duplicate. Although Becken and Mackey (2017) provide interesting insights into the carbon offset offerings by airlines, they did not assess the impact it had on the WTP of passengers. They conclude by recommending best practices, but these recommendations are presented from the author's perspective and do not necessarily align with the attitudes of passengers. Eijgelaar (2011) was excluded because the assessment of the WTP and awareness of carbon offsets were based on a literature review, which was based in large parts on the same papers as this review. For the same reason also Higham et al. (2019) were excluded. However, the assessment of these papers was beneficial for producing this thesis provided valuable insights into the research topic.

The number of papers identified matched the criteria by Pickering and Byrne (2014), who consider a range between 15 and about 300 papers to be sufficient to use their method.

4.2 Descriptive Analysis

The first category, "Research and Journal Data", included information on authors, year, journal category and journal metrics. Data source for the metrics was the CiteScore™ metrics by Scopus, partially supported by the SCIMago Journal Ranking. The timeframe of the studies reached from 2004 to 2020, with Becken (2004) being the earliest and Ritchie, Sie, Gössling, and Dwyer (2020) and Shaari et al. (2020) being the most recent. As it can be seen in Figure 6, peak years are 2014 with a steady decline afterwards and a new peak in 2019. It can be assumed that the number of publications in 2020 will increase, since data collection on this study ended on Sep. 12th, 2020. The timeframe of the studies and the lack of studies before 2007 (except Becken, 2004) can be explained by the circumstance that the earliest offset providers such as Prima Klima Weltweit, Tree Canada or Green Fleet only started operations during the 90s (Gössling et al., 2007) and voluntary carbon offset programs in the aviation industry just getting traction around 2007 (Choi & Ritchie, 2014).

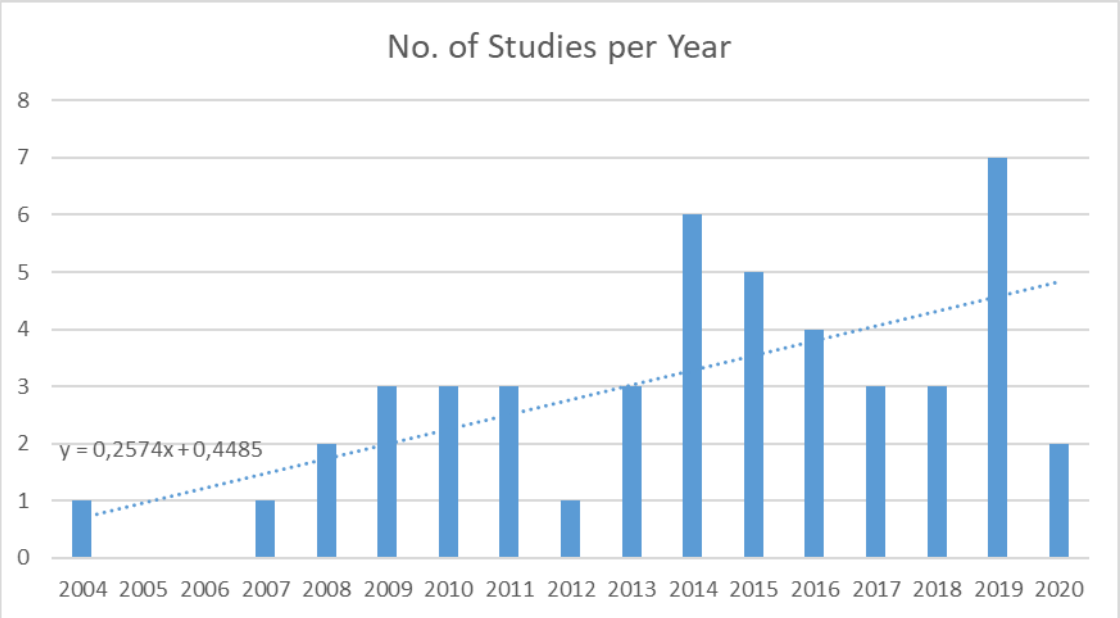

Figure 6: Number of studies by year including linear trend line

Most frequent authors (including co-authorship, shown in Figure 7) where Ritchie Brent with 7 articles (14.89% of total papers), followed by Stefan Gössling, James E.S. Higham and Andy S. Choi, with participation on 4 articles each. Higham and Choi were also the most common first authors. Those two are accounting for 17.02% of the total studies. The low amount of papers increased the risks for bias by strong influences of single authors on the overall results. However, since this study has a narrow focus, it is not unusual to see multiple contributions by single authors who focus on this specific area in their research and publish multiple related papers.

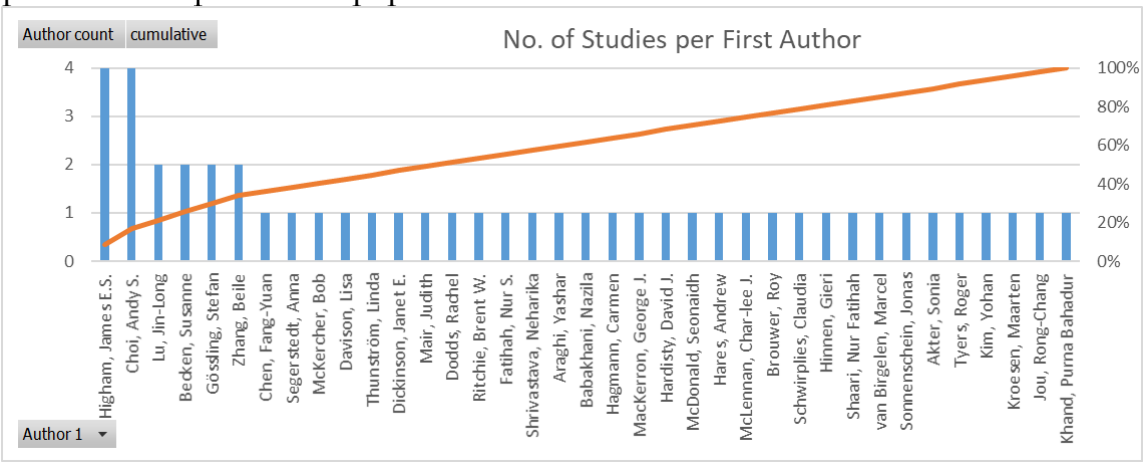

Figure 7: First author's number of studies and share of total

Looking at the Journals the studies were published in, we can see in Figure 8 a strong majority with 12 of 47 (25.53%) being published in the Journal of Sustainable Tourism, followed by the Journal of Travel research (4 articles) and the Journal of Air Transport Management (4 articles).

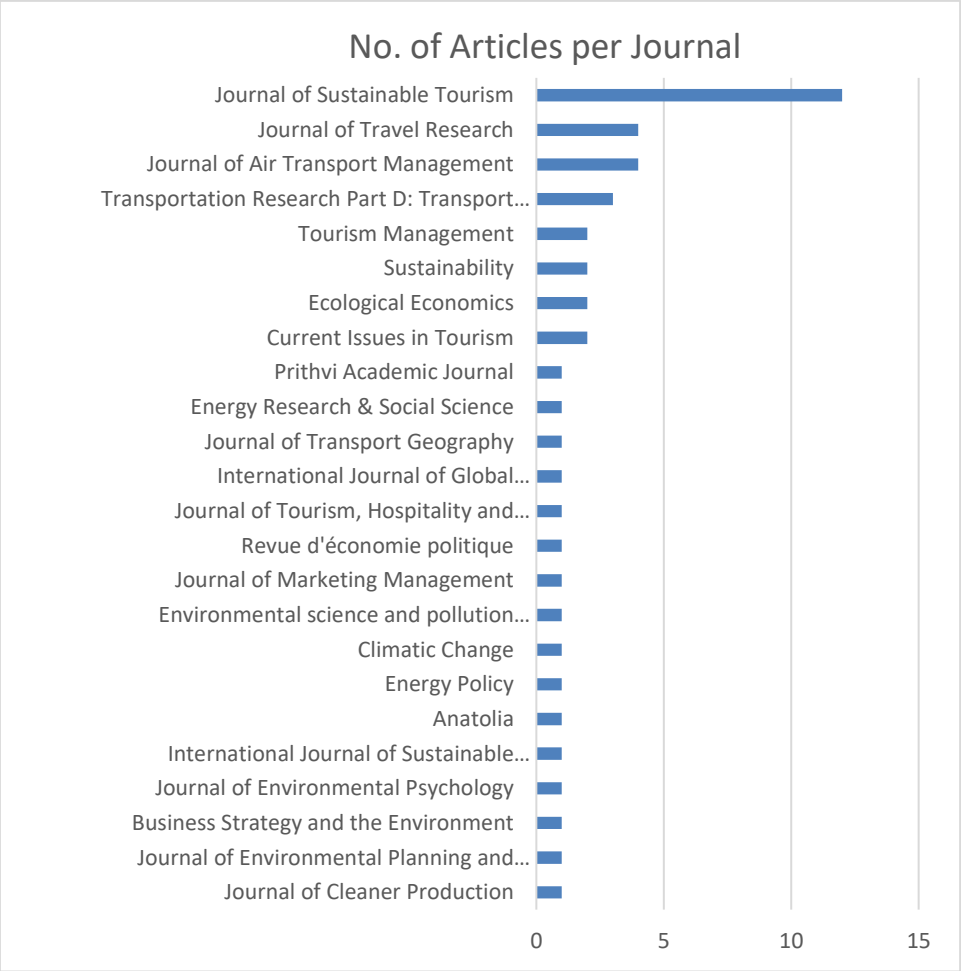

Figure 8: Number of articles per journal

Continuing over to the "Research Design and Approach" category, information on the methodology, study focus and -design as well as airline, airport, country, and population researched was retrieved. With a share of 70%, the majority of the studies were of quantitative nature, with 17% qualitative and 13% with mixed approaches. 37 studies were case studies and 7 of exploratory nature, highlighting the relative novelty of this field of research. One unexpected outcome was the very low number of studies which used behavior observation, being just 2 (Becken, 2007; Tyers, 2018). Surprisingly, there was also the study by Babakhani et al. (2017), who conducted a psychophysiological lab experiment including skin conductance and eye tracking to explore message framing for carbon offsets. This shows that innovative approaches to this topic are feasible and can contribute to the research from a different perspective. Aside from surveys and interviews, 80 different methods were used throughout the studies. Most preferred methods included contingent valuation and focus group research as well as logistic regression and structural equation models.

Another surprising finding was the lack of cooperation between researchers and airlines. Only 5 studies included some form of collaboration with airlines, 3 of those with the Australian national airline Qantas (Babakhani et al., 2017; Zhang et al., 2019b, 2019a), one with SAS and Lufthansa (Gössling et al., 2009),

and one with Malaysia Airlines and Air Asia (Shaari et al., 2020). Within the "Influencing Factors" category, the "Airline" sub-category with its seven factors is the one with the lowest amount of aspects and only includes 13 occurrences in total. This was not expected since about a quarter of the studies asked their participants about if they would be willing to pay for offsets and/or what amount they would be willing to pay. Yet, the connection to the action (booking a flight / buying a ticket) and the way the option to offset is offered to passengers is rarely studied. Only one study (Tyers, 2018) observed actual purchase behavior and found only 0.126% of study participants to offset their latest flight. There is definitely a research gap, which could provide valuable insides on the links between attitudes, behavior and action at the actual point of sale for carbon offsets.

Continent / Country	No. of studies
Africa	**1**
Seychelles	1
Asia	**9**
Hong Kong	1
India	1
Malaysia	2
Nepal	1
Taiwan	4
Australia & Oceania	**13**
Australia	11
New Zealand	2
Europe	**25**
Germany	5
Netherlands	5
Norway	3
Poland	1
Sweden	2
Switzerland	1
United Kingdom	8
North America	**4**
Canada	1
United States	3
n =	**52**

Figure 9: No. of studies per continent and country

As for the geographical distribution of the studies, a clear focus on central and northern Europe as well as Australia can be observed in Figures 9 and 10. In these, all countries which were studied by the researchers were counted, since several studies focused on multiple countries. One example for this is the study by Higham, Cohen et al. (2016) who gathered and compared information from passengers originating in Norway, Germany, the United Kingdom and Australia. The high share of studies from Australia is partially explained by multiple contributions by the authors in this field (e.g. Choi and Zhang), but the interest in this field could also be due to the circumstance that Australia was one of the first countries to introduce a VCO program and Qantas claiming to have the largest VCO program in the world (Zhang et al., 2019b). Additionally, the government

of Australia introduce a carbon tax in 2011, which was abolished in 2014 after political change and has gotten some media attention (Choi, Gössling, & Ritchie, 2018). Media attention might also play a role in some European countries, as the negative environmental impacts of flying gain more attention. Swedish and German press have branded the term "Flygskam" or "Flugscham" (Bösehans et al., 2020) to express a feeling of guilt when travelling by air and being aware of the environmental damage caused, but not changing the behavior to not flying. Another interesting part of this is the study conducted on the Seychelles (Gössling & Schumacher, 2010). This study was not conducted by researchers of the Republic of the Seychelles, but by Gössling and Schumacher, who were researchers with a focus on tourism at the universities of Kalmar (Sweden) and Hildesheim (Germany) at the time. This thesis does therefore not include studies on the issue of carbon offsets from an African perspective. Additionally, no study from the continent of South America could be identified

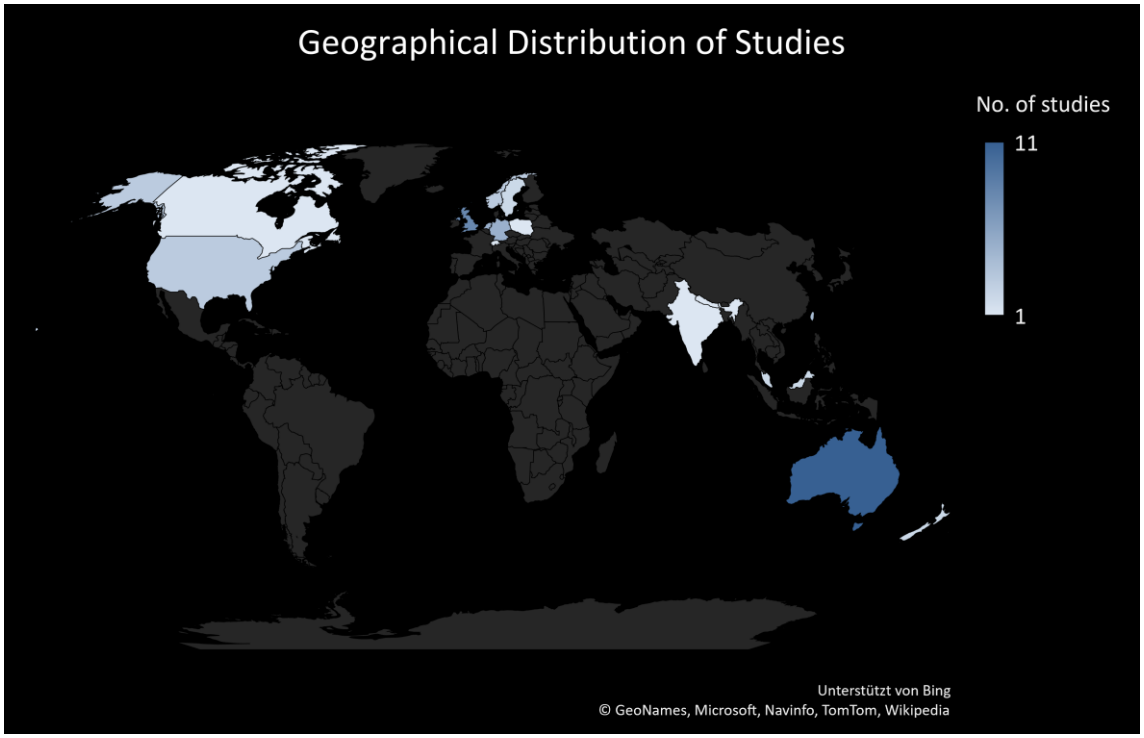

Figure 10: World map including no. of studies per country

Taking a look at the studied population, Figure 11 shows a major influence on the studies. Frequently, the studied population consisted of younger people, students and other people with higher education. This was due to a variety of reasons. Some studies (Babakhani et al., 2017; Thunström, van't Veld, F. Shogren, & Nordström, 2014; Tyers, 2018) explicitly investigated students, whereas other conducted their study in close proximity to a university (Dodds, Leung, & Smith, 2008) or stated societal reasons for a higher participation of young people in a survey (Dickinson, Robbins, Filimonau, Hares, & Mika, 2013). Some of the studies using snowball sampling to identify study participants also included an unproportionally high share of highly educated people (Higham & Cohen, 2011; Higham, Reis, & Cohen, 2016; Kroesen, 2013). The applicability of their respective

results to the general public might still be viable, since various studies have found age and education to be non-influential on the willingness to pay.

AGE	Count
All	38
Young	4
Young majority	5
n =	**47**

GENDER	Count
All	42
Female majority	4
Male majority	1
n =	**47**

SOCIAL	Count
All	34
Government employees	1
Green consumers	1
High educated	4
Students	3
Students & University staff	2
Tourists	2
n =	**47**

FLYING	Count
All	45
economy clas	1
High flying	1
n =	**47**

Figure 11: Differences in researched populations

The data collected from the participants included standard demographic factors, such as age, income and education, behavioral patterns and attitudes related to travel and flights, as well as information related to offsets, airlines, and travel direction. This resulted in 43 different characteristics in this review, which were used as a base to determine the influencing factors on the WTP.

Preferred way of collecting data as seen in Table 2 were surveys, which were conducted in 39 out of the 47 studies. Without the extreme value of 105.942 participants (McLennan et al., 2014) the average survey included about 712 participants. The 14 interviews included on average 30 participants. As for the way the surveys were carried out, Table 3 shows a slight tendency towards online studies (21 compared to 18). In general, no significant structural differences could be found in the results based on the way the surveys were conducted.

Table 2: Methods of data collection

Data Collection	Surveys	Interviews
Count	39	14
Share	73.58%	26.42%
Avg. Participants	3410.31	30.62
without extreme Value	712.11	30.62

Table 3: Approach to survey data collection

Survey Type	Online (specific population)	Online (general population)	Telephone	On site (Questionnaire)	On site (Interview)	Total
Count	7	14	1	11	7	40
Share	17.50%	35.00%	2.50%	27.50%	17.50%	100.00%

4.3 Environmental Knowledge

Separated in the database of this study from the characteristics of the collected information were the aspects of environmental knowledge which the researchers covered in their studies. This was to ensure a proper analysis towards answering the research question of how environmental knowledge was defined by researchers and which aspects they covered. Additionally, information of whether or not study participants had been informed and if so, in which manner, was added into the database. This was done to investigate the impacts of an informed vs. uninformed individual. Whereas some researchers choose to investigate the unbiased opinion of travelers, others specifically focused on how attitudes and behavior would change once passengers were informed and possessed sufficient environmental knowledge (Lu & Wang, 2018). This led to the distribution of approaches shown in Table 4, with slightly more than half of the studies being carried out without providing environmental knowledge to participants. Most commonly the information was presented in written form (see Table 5).

Table 4: Information provided by researchers

Information provided	count	share
yes	20	42.55%
no	27	57.45%
before	4	18.18%
during	17	77.27%
after	1	4.55%

Table 5: Medium used to provide information

Medium used	Count	Share
Videos	1	4.35%
Pictures & Text	2	8.70%
Text	11	47.83%
Interview/Talk	6	26.09%
Other	3	13.04%

The study by Hagmann, Semeijn, and Vellenga (2015) was the only one who provided information to participant's after the survey once the participants expressed their interest in the subject. This shows a certain interest in the topic by passengers, but also points out the unawareness in the first place.

To find out how the researchers defined environmental knowledge in their respective studies, all aspects of environmental knowledge covered were collected and grouped into categories by the overarching theme connecting them. This led to the following graph (Figure 12):

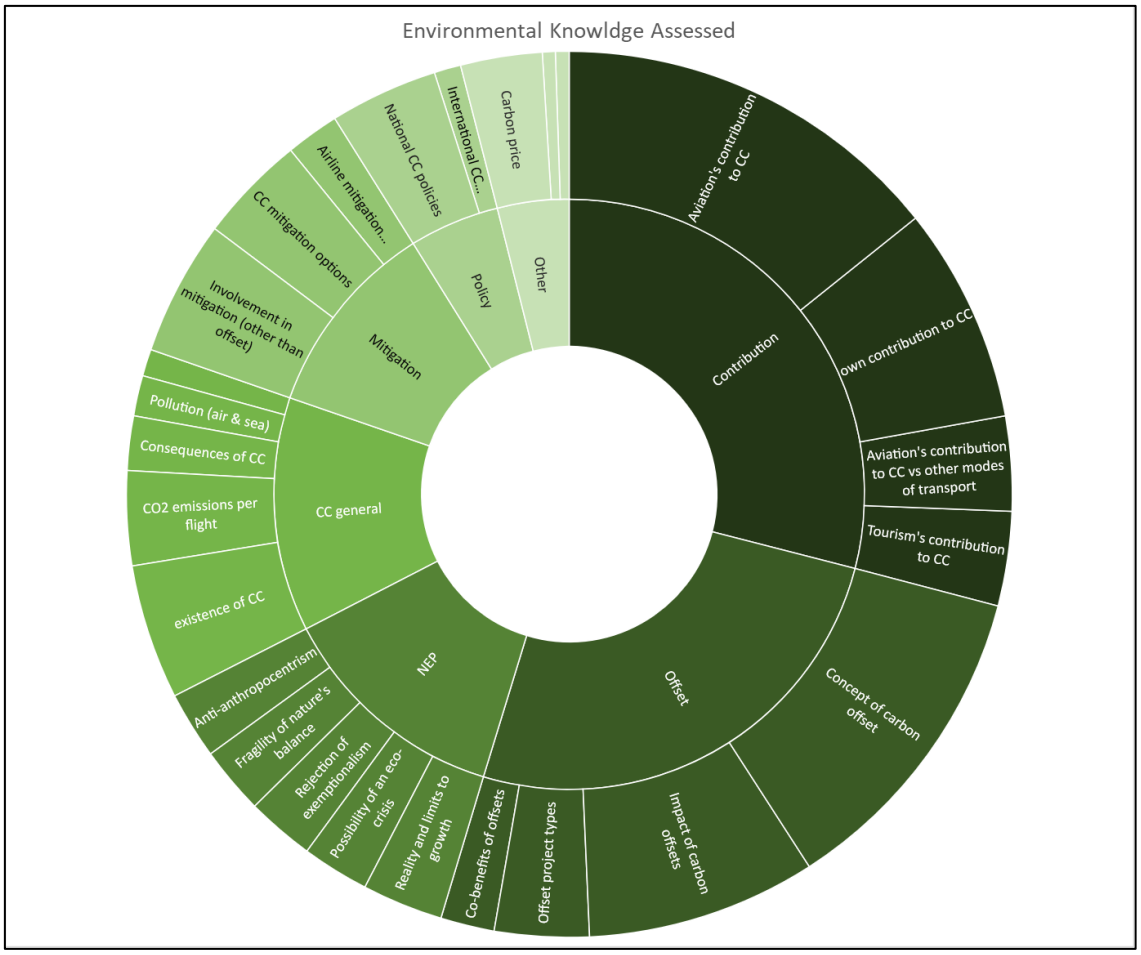

Figure 12: Aspects of environmental knowledge covered, grouped into themes

The largest theme identified was the aspect of contribution to climate change (CC). Predominantly passenger's own contribution and the impact of aviation on CC were assessed in the studies. Additionally, the contribution of tourism (tourist activities aside from (air-)travel to destination) played a role in this context. Six out of seven times these studies also included the own and aviation's contribution and provided a holistic picture of tourism activities. This was to be expected due to the high amount of tourism related studies in this review. The contribution aspect also covered comparative questions and analysis on aviation to other modes of transport.

In terms of offsets, not only were the concept of carbon offsets assessed, but also more detailed aspects, with the impact of carbon offsets being the most common. This covered for example the CC mitigation potential and amount of CO_2 offset per year (Babakhani et al., 2017). The aspect of offset project types included planting trees, renewable energy and CO_2 avoidance projects, as assessed for example by Schwirplies, Dütschke, Schleich, and Ziegler (2019). Subsequently, also co-benefits associated with carbon offsets like replacing wood-based cooking stoves with solar-powered electric ones which also improves health and quality of life were covered (Mair, 2011).

General aspects of CC only played a minor role, with the most frequent aspect being the existence of CC itself. Five studies (Choi, 2015; Choi et al., 2016;

Choi & Ritchie, 2014; Kroesen, 2013; Mair, 2011) were using the New Ecological Paradigm (NEP) scale by Dunlap, van Liere, Mertig, and Jones (2000) in order to assess the environmental knowledge of their study participants. The scale consists of 15 items covering five distinct hypothesized aspects of an ecological worldview and is used to measure pro-environmental orientation of individuals.

4.4 Influences on Willingness to Pay

Over the course of the review, 120 different influencing factors were identified and grouped into the categories "Demographics" (27 factors), "Behavior" (32 factors), "Attitudes" (28 factors), "Offset" (25 factors) and "Airline" (8 factors). Each factor was split up into positive, neutral, and negative impact on the WTP, totaling in 360 characteristics. A first look into the data based on counts revealed consistencies and consensus among the studies as well as expected differences. The summarized overview on the influencing factors with an occurrence in more than two studies can be seen in the tree map (Figure 13).

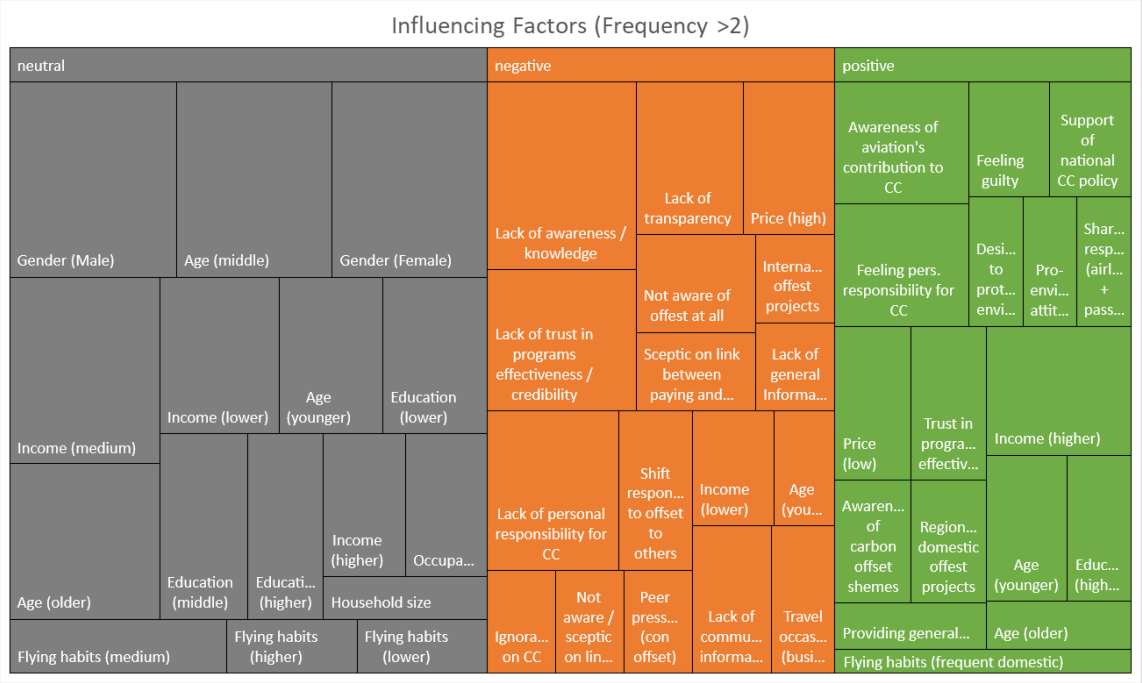

Figure 13: Tree map of influencing factors with a frequency of occurrence >2

Most of the common demographic factors, such as age, gender, income, and education, which were frequently investigated by the researchers; showed differing results with a strong tendency towards neutrality. The role of age and gender as a predictor for the likelihood of paying has been the subject of multiple studies. Mair (2011) tested and rejected the hypothesis that older, female participants would be more likely to hold pro-environmental attitudes and engage in pro-

environmental behavior such as carbon offsets. However, other studies confirmed that older (Fatihah & Rahim, 2017; Lu & Wang, 2018; Shaari et al., 2020) or female participants (Choi & Ritchie, 2014; MacKerron et al., 2009) are more likely to engage in carbon offsets than their counterparts, although no study found both factors to be positive simultaneously.

The reasoning for the differences in the demographic section were manifold and differ based on the background of the study. Fatihah and Rahim (2017) who conducted their study in Malaysia, concluded that older individuals are more concerned about the fate of future generations. In contrast to this, Segerstedt and Grote (2016) who conducted their study in Germany and found younger people to be more likely to be offsetters, suggested that those are more susceptible to marketing campaigns and the promotion of VCOs by travel suppliers. Young age was also often associated with other pro-environmental behavior, attitudes and lifestyle choices, such as being vegetarian or engaging in recycling and energy savings (McLennan et al., 2014). Other demographic factors like nationality, religion or political orientation were occasionally included in the studies. Most notable in this regard were the findings by some researchers (Brouwer et al., 2008; McLennan et al., 2014) that Asian travelers are less likely to offset. These findings can be complemented with the reviewed studies conducted in Asia. Although the adoption rates were below 1% (McKercher et al., 2010; Shaari et al., 2020), the stated WTP during the studies was 74.1% on average. This indicates an even more extreme attitude-behavior-gap in this region but also suggests great potential for the implementation of VCO schemes.

Travel- and flight behavior was also commonly assessed in the studies, yet again, the findings were in some parts contradicting. Whereas some researchers like Akter et al. (2009) found no significant influence on the WTP based on the flight behavior, Araghi et al. (2016) found a higher WTP amongst passengers who flew less frequently. The latter reasoned that consumers who consider flying as less important part of their lifestyle gain more utility from offsetting flights than others. Another approach to classify passengers were the division between international and domestic travelers or short- and long haul flights (Choi & Ritchie, 2014; Gössling & Schumacher, 2010). In this, short haul and domestic flights always increased the WTP compared to long haul flights. The easiest and most reasonable explanation for this is the increase in price of the VCO which happens with the increase in CO_2 emissions on long-haul flights (Brouwer et al., 2008; Gössling & Schumacher, 2010).

Certain travel behaviors also showed influences on the WTP. Since this was only assessed in a couple of studies with various aspects of travel patterns covered, e.g. with or without family (Brouwer et al., 2008), group travel or unaccompanied (Tyers, 2018), or nature and sport/activity tourists (McLennan et al., 2014; Segerstedt & Grote, 2016), it is not viable to draw conclusions from this outside the respective study settings. Only business travel as a travel occasion was assessed in more than two studies and was found more frequently to be of negative influence (Jou & Chen, 2015; Lu & Shon, 2012; Lu & Wang, 2018; McLennan et al., 2014) than neutral (Brouwer et al., 2008; Schwirplies et al., 2019). No study

found a positive correlation in this regard. This is most likely due to the circumstance that business travelers are send by their companies and are not involved in the booking process personally. McLennan et al. (2014) pointed out that businesses might engage in company-wide carbon offsetting or offsetting emissions on the traveler's behalf, therewith making actions of the travelers themselves obsolete.

Other behavior was only sporadically assessed, but brought forward some interesting findings, such as that people who used video conferences before are less likely to offset (Lu & Wang, 2018) or people who donate to other charities being more likely to offset (Schwirplies et al., 2019).

Financial aspects in general were common across all categories and had a strong tendency towards positively influencing the WTP if lower costs were involved. This not only refers to the absolute price of the VCO, shown for example in the studies of Shrivastava, Sharma, and Chaklader (2019) and Sonnenschein and Mundaca (2019), but also connects to the financial situation of the study participants based on their demographics like income and occupation as some studies like Jou and Chen (2015) and Khand (2019) point out. Additionally, Choi and Ritchie (2014) and Mair (2011) highlight the convenience of purchase as crucial for the adoption of VCOs. These findings support the argumentation of Schwirplies et al. (2019) and Sonnenschein and Mundaca (2019) who both referred to the low-cost hypothesis in their respective studies. This hypothesis argues that individuals environmental concerns predominantly influence their environmental behavior in situations with low costs and little inconvenience (Diekmann & Preisendörfer, 2003).

One of the most present themes in the papers was the aspect of responsibility. In this area, there was a broad consensus on the positive influence of feeling personal responsibility (covered in Chen, 2013; Davison, Littleford, & Ryley, 2014; Hares, Dickinson, & Wilkes, 2010; van Birgelen, Semeijn, & Behrens, 2011), and the negative influence of a lack thereof (covered in Becken, 2007; Kroesen, 2013; Lu & Shon, 2012). These factors were complemented by passenger's shift of responsibility to others (Gössling et al., 2009; Hardisty et al., 2019), which negatively affected the WTP, and shared responsibility being a positively influencing factor (Gössling et al., 2009; Lu & Shon, 2012; Schwirplies et al., 2019).

Although it was assumed that this consensus would also occur within the awareness of aviation's contribution to CC and skepticism on the link between aviation and climate change, the studies reviewed presented differing results. Choi et al. (2016) found lower WTP for voluntary actions amongst their study participants the more they believed their flight contributed to climate change. The authors suggest that this could be due to a shift of responsibility, which was also assessed by Gössling et al. (2009) and Lu and Shon (2012). Gössling et al. (2009) also found climate sceptics to be not significantly less likely to offset the carbon emissions of their flight, with a share of 63% of study participants compared to 72.9% of participants grouped as *"worried"* travelers who were aware of the contribution their flights had on the climate (Gössling et al., 2009). The same study also found that travelers see themselves to be the least responsible actors,

shifting the responsibility to aircraft manufacturers, airline industry, governments or intergovernmental organizations. In relation to this, Choi and Ritchie (2014) even found higher WTP in CC-sceptics compared to others, arguing that non-sceptic passengers, again, might consider other parties to be responsible for the emissions. Climate sceptics could also support offset programs for other reasons than fighting climate change, for example by supporting co-benefits like nature conservation and biodiversity protection by forest-based offset programs (Choi & Ritchie, 2014)

The factors surrounding the offsets themselves went into two different directions. On one hand, researchers assessed which program types and methods, e.g. planting trees vs. renewable energy, or domestic vs. international offset projects were more preferred by participants (Hinnen et al., 2017; Schwirplies et al., 2019). On the other, they assessed passenger's attitudes towards offsets, resulting in a rather negative picture dominated by aspects of awareness (e.g. Dodds et al., 2008), knowledge (e.g. Fatihah & Rahim, 2017), transparency and trust in programs (e.g. Schwirplies et al., 2019) as well as the lack thereof. All three dimensions can be found among the most common negatively influencing factors (see Figure 13). This has to be viewed in some part in the historical context, as the concept of VCOs is relatively new, naturally meaning a low level of awareness and knowledge on those. Dodds et al. (2008), being one of the earlier studies, found not just a lack of knowledge and awareness on carbon offsets, but also a lack of sources to obtain carbon offsets from and a lack of agreed upon industry standards. This is in line with the study by Gössling et al. (2007) who studied the state of offsetting providers at the time. These problems could be the root cause for people's ongoing lack of trust in the efficiency of such programs, or as some researchers put it: a skepticism on the link between paying money and saving the environment (Higham, Reis, & Cohen, 2016; Zhang et al., 2019b).

As mentioned earlier, factors relating to airlines were less commonly assessed, with the most prevalent factor being the lack of communication by airlines with five occurrences, which amongst others Zhang et al. (2019b) and Higham, Reis, and Cohen (2016) investigated. The aspect of message framing, which in this case is referring to the way the airline is presenting information on carbon offsets and supposedly encourage the purchase decision of the passengers, was assessed by Babakhani et al. (2017) and Zhang et al. (2019b). Both studies were carried out independent from each other and used different methods, while both using the massage presented by the Qantas airline in their research. In both studies, the Qantas message, meaning the actual message in practical use, received the lowest attention from studied participants. This is pointing towards possible issues with the way VCOs are sold and marketed, but also offers opportunity for improvements leading to an increase in purchases (Zhang et al., 2019b).

Overall, the assessed factors differed based on the method of the study. Whereas quantitative studies for the most part included information on demographic factors and behavioral patterns, qualitative studies seemed to focus on the attitudes of the participants. One aspect which was only brought forward in qualitative studies was "feeling guilty" for flying. Even though, as mentioned

earlier, this aspect has been getting media attention (Bösehans et al., 2020), it was not covered in any of the quantitative studies.

Over the course of this study, two additional aspects which were suspected to influence the WTP were investigated. The first one, which sheds some light on how environmental knowledge affects passengers, was the effect of provided information on passenger's stated WTP. It was assumed that there would be a difference between study participants who were informed about environmental aspects of their flight and carbon offsets before the study and uninformed participants. For this analysis, the share of people who stated that they would be generally willing to pay was used instead of the exact amounts of WTP, since the prices varied heavily depending on the financial situation within the respective countries. While Akter et al. (2009) found the average WTP to be 43 EUR per trip in the Netherlands, Fatihah and Rahim (2017) found it to be 6.1 MYR, translating to 1.24 EUR respectively in Malaysia.

To test the influence on the WTP, a t-test was carried out resulting in a t-value of 1.2144, which did not meet the critical value of 1.8331. Although the overall average of informed participants is about 13% higher (64.06% compared to 51.15% for uninformed), there is no statistically significant difference between the two groups. However, the respective boxplot (Figure 14) of this question revealed a denser range of the stated WTP compared to uninformed participants.

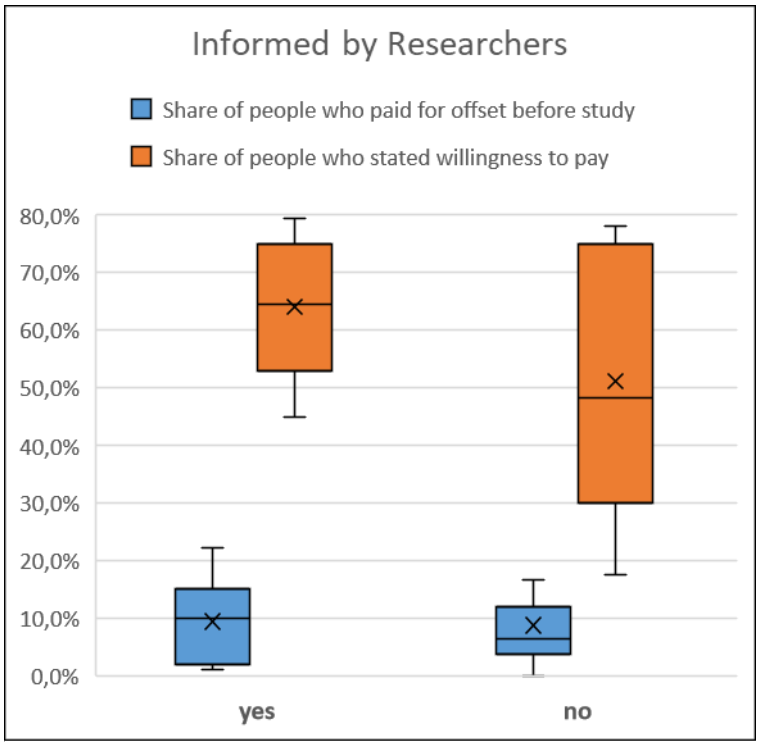

Figure 14: Stated WTP and offset before by aspect "informed by researchers"

The boxplot also includes the share of people who stated they had purchased carbon offsets before the study. This is showing the major difference between the attitude of being willing to offset, and the actual behavior (or action) of buying offsets. Although carbon offsets are usually seen as a way to avoid behavior change in travel- or flight behavior (Higham, Reis, & Cohen, 2016; McDonald,

Oates, Thyne, Timmis, & Carlile, 2015) we can see an attitude-behavior gap within the WTP as well.

The next aspect investigated was the change of WTP over time. Since the global voluntary offset market did not increase steadily in the past (Hamrick & Gallant, 2017), it is of interest to see how the share of people who offset and the stated WTP have been changing. Even though the amount of studies and therefore the interest among the research community shows a positive linear trend (see Figure 6) it was not expected to find a difference in the WTP since adoption rates are still shown to be low in more recent studies (Ritchie et al., 2020; Schwirplies et al., 2019). The correlation analysis shown in Figure 15 confirmed the assumption, with the correlation values of R1 = 0.2197 and R2 = 0.1342 being insignificant.

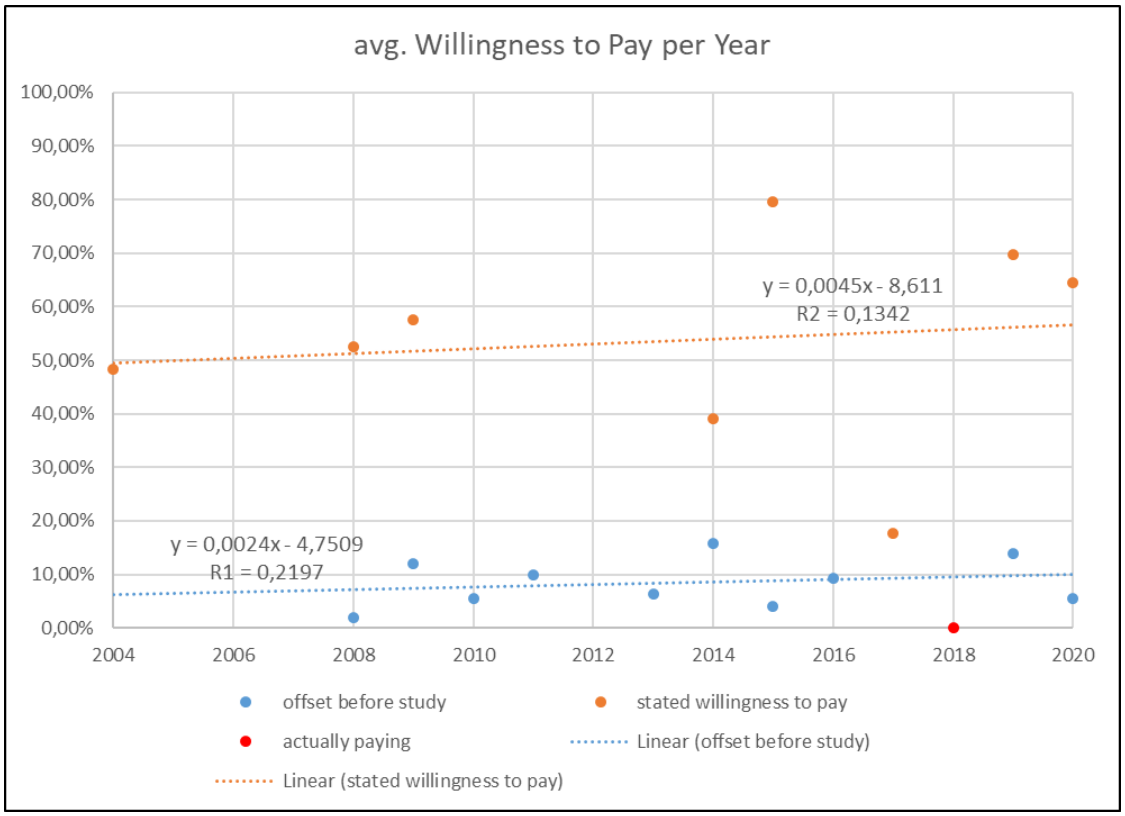

Figure 15: Correlation of average willingness to pay and year

4.5 Network Analysis

By combining the environmental aspects with the influencing factors they are thematically related to, the incidence matrix shown in Figure 16 was produced. The relating network analysis shown in Figure 17 was kept in a simple unicolor design and shows the unweighted connections according to the edge list.

	Feeling pers. responsibility for CC	Lack of personal responsibility for CC	Shift responsibility to offset to others	Shared responsibility (airline + passen	Awareness of aviation's contribution	Not aware / sceptic on link between	Aware of share of people who offest	Technical understanding of CC	Positive anticipated emotions	Negative anticipated emotions	Feeling guilty	Concern for future generations	Concern about the environmental	Concern about "free-riders"	Avoid disasters	Reduce damage costs	Protect Wildlife / Biodiversity	Desire to protect environment	Pro-environmental attitudes	Ignorance on CC	Ignorance on offsets	Ecocentric attitude	"Warm glow"	Peer pressure (pro offset)	Peer pressure (con offset)	Social embeddedness	Support of national CC policy	Support of international CC policies	Offset before	Awareness of carbon offset shemes	Not aware of offest at all	Lack of transparency	Lack of awareness / knowledge	Sceptic on link between paying and s	Lack of trust in programs effectivene	Trust in programs effectiveness	Lack of general Information provided	Providing general information	Providing information on results / suc	Carbon tax / price already in place	Lack of incentives to offset	"upstream offset" for fuel productio	Regional/domestic offest projects	International offest projects	Planting trees / afforestation	Renewable Energy	Co-benefits	Certified programs	Offering offset	Convenience of purchase	Inconvenient purchase	Price (low)	Price (high)	Lack of communication / informatio	Lack of transparency	Lack of trust in airline	Trust in airline	No offset offered	Not aware of airline's offset program	Ticket price (high)	Eco-label
existence of CC	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consequences of CC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Technical understanding of CC	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pollution (air & sea)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 emissions per flight	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
own contribution to CC	1	1	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aviation's contribution to CC	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Tourism's contribution to CC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aviation's contribution to CC vs ot	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CC mitigation options	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Involvement in mitigation (other th	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Airline mitigation measures	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0
Concept of carbon offset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Impact of carbon offsets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Offset project types	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Co-benefits of offsets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
National CC policies	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International CC policies	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Green branding	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Airline EMS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon price	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reality and limits to growth	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anti-anthropocentrism	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fragility of nature's balance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rejection of exemptionalism	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Possibility of an eco-crisis	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 16: Incidence matrix used for network analysis

Figure 17: Network plot

The plot revealed two major clusters. The larger, denser cluster on the top left consists of the own contribution to CC and the concept of carbon offsets with both being linked to 7 factors each. Bridging those two aspects is the lack of transparency as the connection between the concept of carbon offsetting and airline mitigation measures as well as aviation's contribution to CC. As for the own contribution to CC, we can see ties to various aspects covering the aspects of awareness and responsibility. This is the case for the factors surrounding the concept of carbon offsets, as they also relate to awareness, aspects on information and also ignorance. Awareness of carbon offset schemes, not aware of offsets at all and offset before were also linked to CC mitigation options. Aviation's contribution to CC, which is located in between the concept of carbon offsets and the own contribution, is sharing certain aspects between both but is heavily leaning towards the themes of responsibility and awareness. A more detailed view of this is shown in Figure 18.

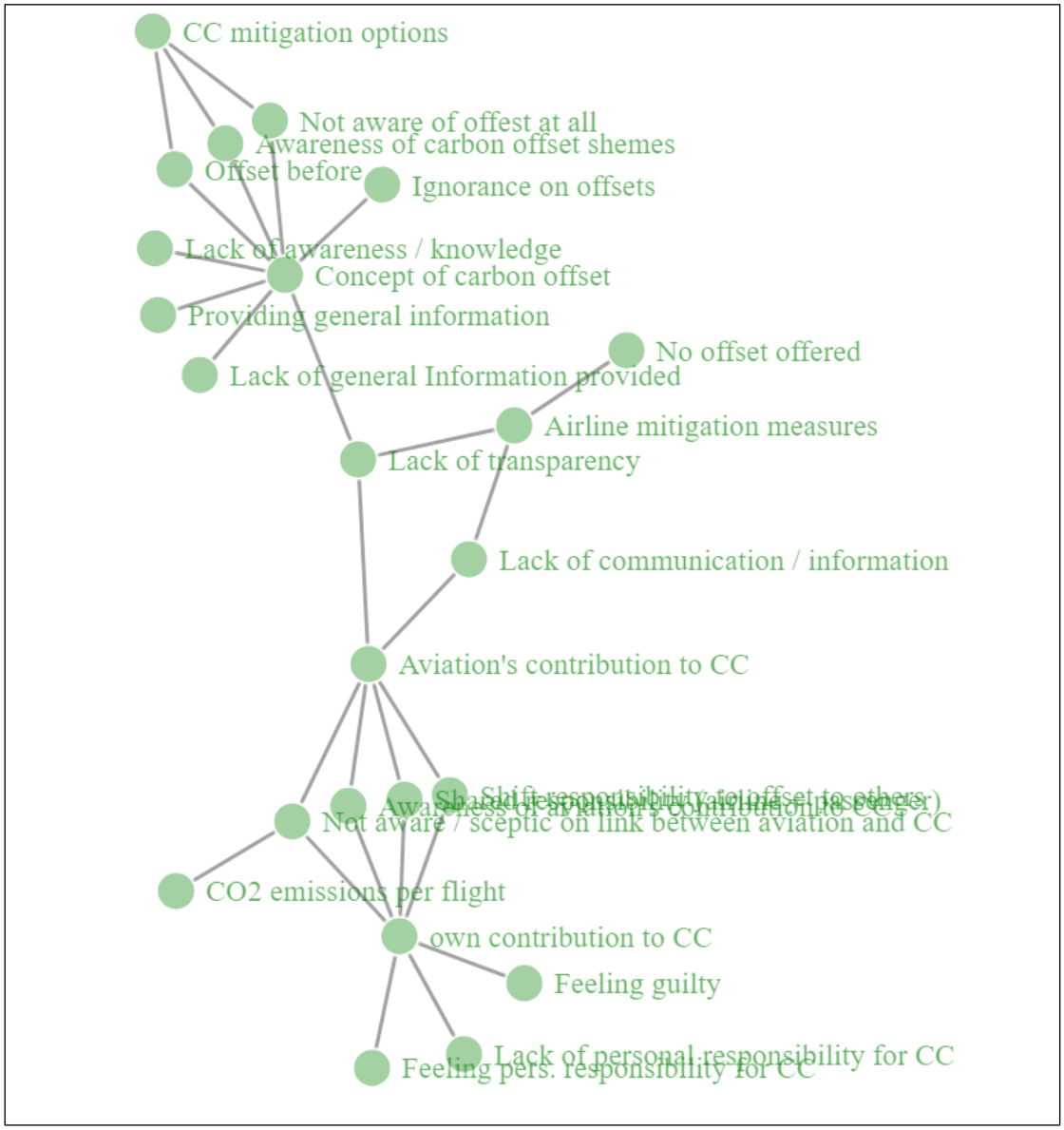

Figure 18: Detailed view of network plot section (1)

The second cluster chained four out of five aspects of the NEP and general CC aspects together with nature related influencing factors, such as a desire to protect the environment and wildlife and biodiversity which were connected to the fragility of nature's balance and pollution (air & sea). Further down the chain we can see concerns which people expressed, namely for future generations and the environment. This connected to the possibility of an eco-crisis. With the possibility of an eco-crisis as well as the consequences of CC and their link to people's reasoned reactions to CC such as reduce damage costs and avoid disaster, we get a cluster which includes most, yet not all influences related to the impacts and consequences with individual's perceptions of climate change. Figure 19 presents this cluster in more detail.

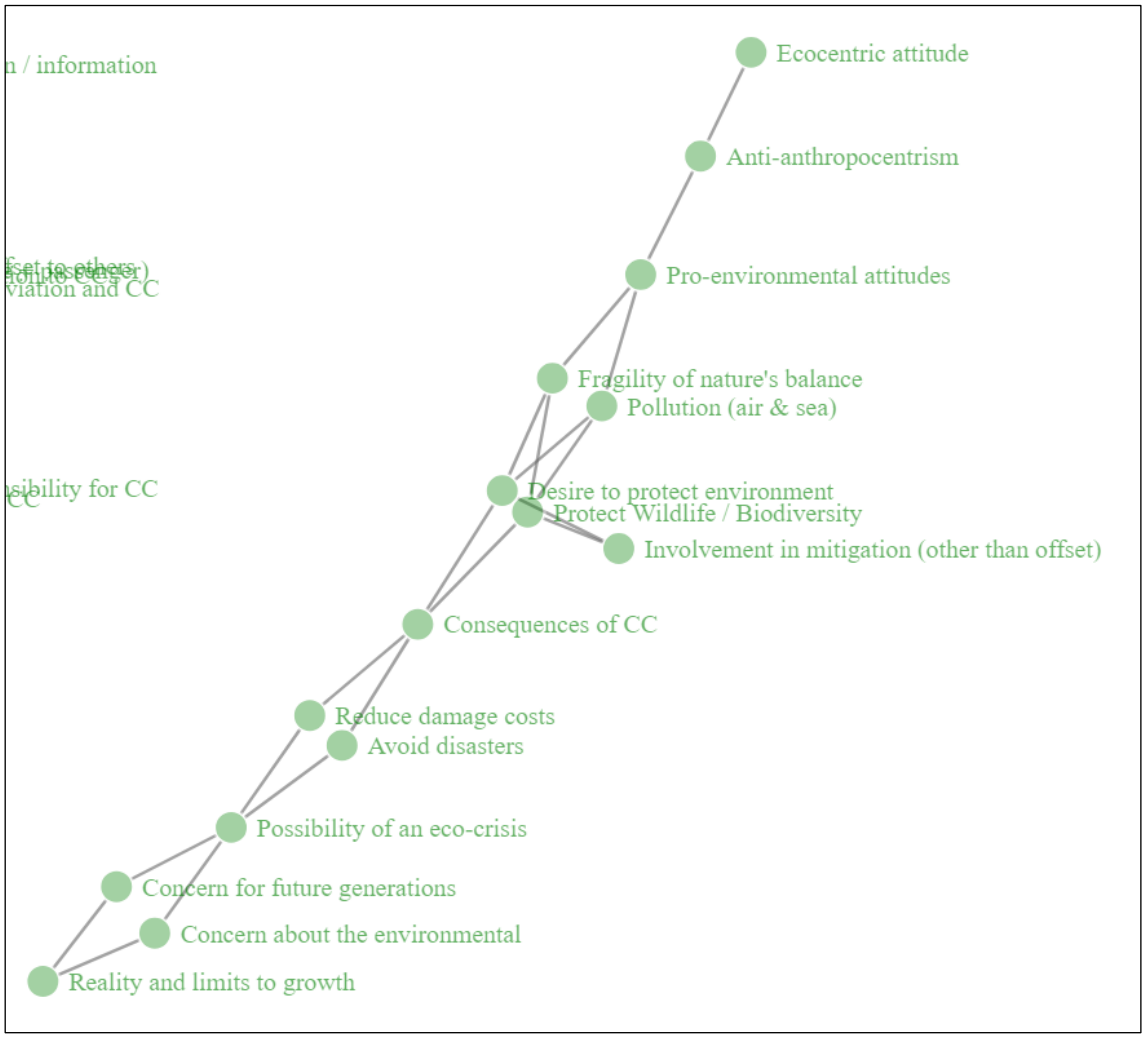

Figure 19: Detailed view of network plot section (2)

The aspects of environmental knowledge which were grouped under the carbon offset category were split up into several clusters, leaving two distinct clusters separated from each other – one surrounding offset project types and the co-benefits, the other one on the impact of carbon offsets. Whereas impacts connect to the aspects of trust and skepticism as well as information, the project types and

co-benefits are linked to certification, location of project and kind of project/offset mechanism. These are shown in Figure 20 and 21.

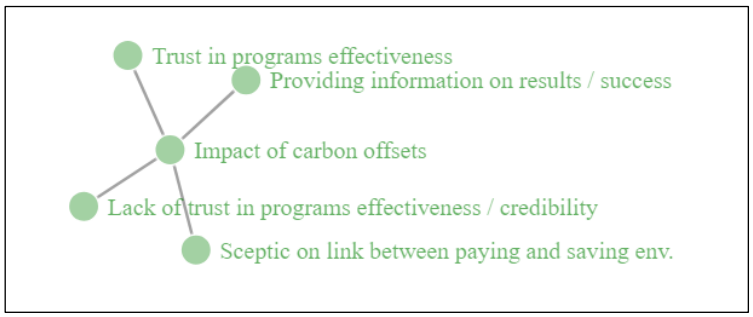

Figure 20: Detailed view of network plot section, offset (1)

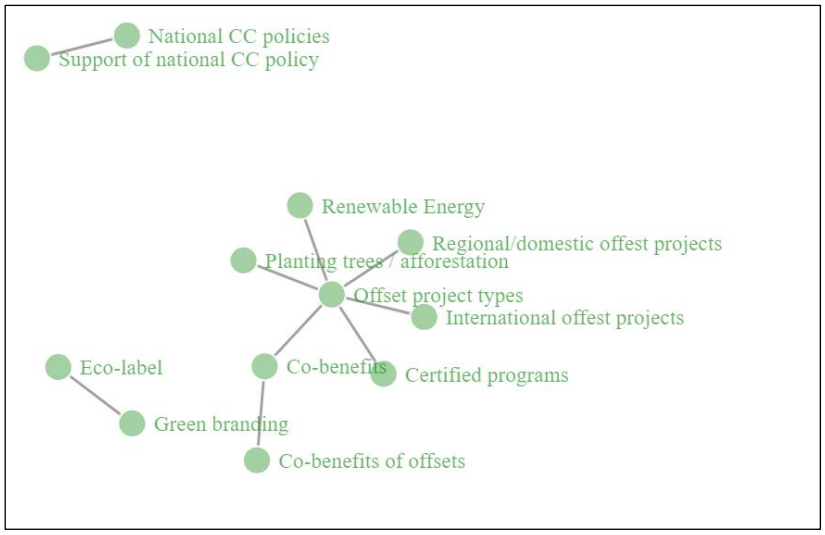

Figure 21: Detailed view of network plot section, offset (2)

Certain aspects only linked to their respective counterpart, creating a lone pair. This was the case with national and international CC policies and the support thereof and the carbon price and the carbon tax / price already in place. Additionally, the eco-label and green branding as well as the technical understanding of CC created pairs. The latter surprisingly not related to the second cluster involving other issues surrounding rather "practical" aspects of CC. Existence of CC and the rejection of exceptionalism, the only aspect which was not in the chain-cluster with the NEP aspects, related to the existence of CC and the respective ignorance.

With this, the network overall revealed two major clusters interlinking distinct aspects of environmental knowledge with the influencing factors identified in this study. On the one side, aspects related to the contribution to climate change are linked predominantly to factors concerning responsibility and awareness. On the other, general CC aspects and the NEP are connected to environmental concerns and mitigation measures.

5 DISCUSSION & CONCLUSION

Voluntary carbon offsets in general and the passenger's perspective on them in particular are a comparatively new and little researched field in the scientific community. The studies presented in this review provided a broader perspective on the links between passenger's environmental knowledge and voluntary carbon offsets.

5.1 Carbon Offsets and the Environment

Although there were major changes in environmental policies in aviation over the timespan of the studies covered in this review, like incorporation of aviation into the EU ETS in 2012 (European Commission, 2020), the Paris Agreement as a historical milestone in the fight against climate change in 2015 (UNFCCC, 2015) and the implementation of CORSIA in 2016 (ICAO, 2020), the emissions of the aviation sector continued to rise (Ritchie, 2020). Impacts of the industry on the climate and the problem of increasing passenger numbers has long been known (IPCC, 1999), yet actions remained scarce up to the implementation of CORSIA which is criticized for its low level of ambition, not capping emissions and exempting a large share of routes (Hedley et al., 2016).

The industry has shown a strong objection of national regulations like carbon taxes (IATA, 2020) and continues to pursue a strategy for growth without limiting emissions but instead relying on technological advancements and offsets (ICAO, 2020). The effects of technological advancements however remain questionable (Peeters et al., 2016). The same is in part also true for carbon offsets, with the basic principle of carbon offsetting by sequestration through forests and its impact on the climate still being debated (Becken & Mackey, 2017; Cook-Patton et al., 2020). Additionally, offsetting is frequently being discussed controversially as a way to shift responsibility from the aviation industry onto consumers (Gössling et al., 2009) or just as a guilt reducing opportunity for people to continue flying instead of avoiding emission completely by switching to other modes of transports or avoid travel completely (Bösehans et al., 2020; Higham et al., 2014). Yet, VCOs offer an opportunity for passengers to reduce their environmental impact independent from industry or political actors. The lack of serious commitments by the industry and hesitant policy-makers show that a pure reliance on international policies and industry strategies might not lead to the immediate ambitious reductions in CO_2-emission demanded by the Paris Agreement (UNFCCC, 2015) to effectively reduce the impact on climate change.

Other mechanisms such as a mandatory carbon tax might seem more applicable and effective, but, as the example of the revoked Australian carbon tax shows (Choi, 2015), may face opposition by citizens and industry. This is also

pointed out by Higham, Reis, and Cohen (2016), who's study across four countries showed varying acceptance and preferences of different mechanisms amongst their interviewees based on nationality.

Furthermore, carbon offsets do not only serve to just equalize or counteract the amount of GHG produced, but also generate a wide variety of co-benefits within the projects, like benefits to human health and biodiversity conservation (MacKerron et al., 2009; Tyers, 2018). Aside from those direct impacts, well-managed VCOs can also provide benefits by increasing media attention and raising awareness for climate change, indicating to policy-makers the willingness of consumer to pay for pro-environmental choices (MacKerron et al., 2009). Therefore, making carbon offsets a suitable way to mitigate harm on the environment.

Environmental movements and the growing pressure of the climate crisis might start the already notable increase in the uptake of carbon offsets in some regions (atmosfair gGmbH, 2020b; Bösehans et al., 2020) to scale up in other markets as well in the near future. Therewith providing additional resources for the global fight on climate change.

5.2 Findings

One important research gap identified by this study is the missing connection between passenger's attitudes on carbon offsets and the actual behavior at the point of sale, being the booking process or an individual purchase from an offset provider. Those studies who did include factors related to airlines consistently found a lack of communication, lack of information and in general no positive influencing factors on part of the airline (Babakhani et al., 2017; Gössling et al., 2009; Higham, Reis, & Cohen, 2016; Kim, Yun, & Lee, 2014; Zhang et al., 2019b). Although Becken and Mackey (2017) found that about a third of all airlines engaged in carbon offsetting, yet they offered in part insufficient information on certification, standards, emission calculation, project types and the type of credits used. A lack of communication on part of the airlines and the inefficiency of messages used in this regard (Babakhani et al., 2017; Zhang et al., 2019a) could be a major hindering factor for the engagement of passengers with VCOs.

This review also found a high amount of studies which observed no significant differences in demographic factors. These were contradicted by other studies suggesting that the geographical and cultural background is playing a role in predicting which groups are more likely to purchase VCOs or are at least more susceptible towards them. An exception in this are financial aspects. Financial influences across all categories, ranging from demographic factors of income and occupation (Khand, 2019; Shaari et al., 2020) to the price of VCOs themselves (Akter et al., 2009; Higham, Reis, & Cohen, 2016; Sonnenschein & Mundaca, 2019) were consistent across studies and in line with the low-cost hypothesis by Diekmann and Preisendörfer (2003), always showing a better financial situation of an individual and lower cost involved to be a positive influence on the WTP.

Additionally, this study found some indication of a higher WTP for participants who were informed of the environmental issues related to aviation compared to non-informed, with a mean of 51.15% to 64.06%. Although this could not be confirmed with statistical significance, future studies with a broader approach including not only VCOs in the context of flights but also in general could provide a sufficient data set to achieve the desired significance on this question.

Even less significant change was, however, observed in the adoption of WTP over the years, which is somewhat contradicting to the prior noted recent increased interest in offsets (Bösehans et al., 2020) and growth of offset providers (atmosfair gGmbH, 2020b). This could indicate that upcoming studies in an EU context might find a spike in WTP or market share of voluntary offsets, representing current pro-environmental movements.

To answer the first research question, it was observed how researchers defined environmental knowledge and which aspects they covered. This led to a wide variety of factors, with aspects surrounding the contribution to climate change as the most prevalent. Additionally, aspects related to carbon offsets were assessed, ranging from knowledge about the mere concept to project types and their co-benefits. Some researchers made use of the New Ecological Paradigm by Dunlap et al. (2000) to measure environmental attitudes, although these were only a minority of the overall number of studies. Less common were general climate change aspects and mitigation potentials, which included the existence of climate change itself. Unfortunately, these studies still found climate change sceptics and deniers amongst their participants (Becken, 2004; Dickinson et al., 2013; Thunström et al., 2014). Climate policies and a technical understanding of climate change only played a minor role.

The second research question was approached by creating the network analysis to investigate how the environmental knowledge of the passengers effected their willingness to pay, and which specific factors were supporting or hindering. Most notable aspects in this were the recognition of aviation's contribution and the own contribution to climate change. The subsequent responsibility passenger's felt or rejected consistently played a key role in the engagement with VCOs. Factors covering the awareness on the other hand, which were also linked to the own and aviation's contribution to CC, did not had the same consistency. Although frequently being noted to have a positive influence if aware and negative influence if not, these factors contradicted assumptions and revealed differing attitudes leading to denial of- and shifts in responsibility (Choi et al., 2016; Choi & Ritchie, 2014; Gössling et al., 2009). This leads to the conclusion that mere awareness campaigns may not always be an appropriate way to encourage passengers to offset their emissions. Increasing the sense of responsibility might be a more suitable way in this regard.

While the mere concept of carbon offsets was rather frequently included as an aspect of environmental knowledge, other components such as its impact, project types and co-benefits were assessed less frequently. In addition to this, the network analysis showed a separation between the concept and impacts of carbon offsets, each being linked to widely differing influencing factors. This information could be useful for airlines or offset providers in communicating VCOs

to the consumer and increase engagement. For example, by promoting offset types which are preferred by consumer and create social co-benefits.

5.3 Limitations

One important limitation which has to be noted is the circumstance that only papers written in English and published in peer-reviewed Journals were included into this study. Some book chapters and conference papers have been identified throughout the database search, even though the search parameters were set to only include journal articles. This indicates to some degree the availability of potential additional research to include in future studies with a broader scope.

The English language was chosen since it is the predominant language in research (Hamel, 2007) and therefore would bring forward the most results as well as ensuring an international perspective. The geographical distribution of studies shows a large share of studies from native English speaking countries, namely Australia and the United Kingdom, with no contributions from the continent of South America and only one African study (conducted by European researchers, see Gössling & Schumacher, 2010). Although some studies from Asia could be identified, there were notably no studies from mainland China. It can therefore not be determined whether carbon offsets are just not of interest for the research community in those regions, or if the review missed them due to the limitations of the language.

5.4 Outlook and Future Research

Although the SARS-CoV-2 pandemic has brought the airline industry to a temporary hold, the long-term consequences remain unpredictable. It is unsure if the growth of passenger numbers seen in past years will continue after the pandemic or not. An early study on the situation by Suau-Sanchez, Voltes-Dorta, and Cugueró-Escofet (2020) highlighted the concern of experts on the role of business travel, which might undergo long-lasting changes in demand due to the increased adoption of teleworking and the digital transformation pushed by the crisis. On the other hand, the experts were less concerned about the demand in leisure travel activity and expected a quicker recovery, albeit pointing out a reduction in disposable income of passenger's due to the economic effects of the pandemic. While airlines might set aside environmental policies and investments due to immense cost pressure and struggle for survival (Amankwah-Amoah, 2020), the impacts on passenger's attitudes and behavior towards voluntary offsets might not necessarily be linked to the state of the industry and take a different route. Future research has the opportunity to observe and investigate changes in passenger's perceptions in a re-emerging market. Researchers will be able to

accompany future developments and changes in environmental behavior and attitudes in a unique situation, which offers valuable insights on the much-needed transition towards a more sustainable aviation industry and the adoption of pro-environmental practices amongst passengers.

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APPENDIX:

List of Literature used in the SQLR

Authors	Year	Title
Akter, Sonia; Brouwer, Roy; Brander, Luke; van Beukering, Pieter	2009	Respondent uncertainty in a contingent market for carbon offsets
Araghi, Yashar; Kroesen, Maarten; Molin, Eric; van Wee, Bert	2016	Revealing heterogeneity in air travelers' responses to passenger-oriented environmental policies: A discrete-choice latent class model
Babakhani, Nazila; Ritchie, Brent W.; Dolnicar, Sara	2017	Improving carbon offsetting appeals in online airplane ticket purchasing: testing new messages, and using new test methods
Becken, Susanne	2004	How Tourists and Tourism Experts Perceive Climate Change and Carbon-offsetting Schemes
Becken, Susanne	2007	Tourists' Perception of International Air Travel's Impact on the Global Climate and Potential Climate Change Policies
Brouwer, R.; Brander, L.; van Beukering, P.	2008	"A convenient truth": air travel passengers' willingness to pay to offset their CO_2 emissions
Chen, Fang-Yuan	2013	The intention and determining factors for airline passengers' participation in carbon offset schemes
Choi, Andy S.	2015	An experimental study to explore WTP for aviation carbon offsets: the impact of a carbon tax on the voluntary action
Choi, Andy S.; Gössling, Stefan; Ritchie, Brent W.	2018	Flying with climate liability? Economic valuation of voluntary carbon offsets using forced choices
Choi, Andy S.; Ritchie, Brent W.	2014	Willingness to pay for flying carbon neutral in Australia: an exploratory study of offsetter profiles
Choi, Andy S.; Ritchie, Brent W.; Fielding, Kelly S.	2016	A Mediation Model of Air Travelers' Voluntary Climate Action
Davison, Lisa; Littleford, Clare; Ryley, Tim	2014	Air travel attitudes and behaviours: The development of environment-based segments

Dickinson, Janet E.; Robbins, Derek; Filimonau, Viachaslau; Hares, Andrew; Mika, Mirosław	2013	Awareness of Tourism Impacts on Climate Change and the Implications for Travel Practice
Dodds, Rachel; Leung, Markus; Smith, Wayne	2008	Assessing Awareness of Carbon Offsetting by Travellers and Travel Agents
Fatihah, Nur S.; Rahim, Abdul A.	2017	The Willingness to Pay of Air Travel Passengers to Offset THeir Carbon Dioxide (CO_2) Emissions: A Putrajaya Resident Case Study
Gössling, Stefan; Haglund, Louise; Kallgren, Helena; Revahl, Milla; Hultman, Johan	2009	Swedish air travellers and voluntary carbon offsets: towards the co-creation of environmental value?
Gössling, Stefan; Schumacher, Kim Philip	2010	Implementing carbon neutral destination policies: issues from the Seychelles
Hagmann, Carmen; Semeijn, Janjaap; Vellenga, David B.	2015	Exploring the green image of airlines: Passenger perceptions and airline choice
Hardisty, David J.; Beall, Alec T.; Lubowski, Ruben; Petsonk, Annie; Romero-Canyas, Rainer	2019	A carbon price by another name may seem sweeter: Consumers prefer upstream offsets to downstream taxes
Hares, Andrew; Dickinson, Janet; Wilkes, Keith	2010	Climate change and the air travel decisions of UK tourists
Higham, James E. S.; Cohen, Scott A.; Cavaliere, Christina T.	2014	Climate Change, Discretionary Air Travel, and the "Flyers' Dilemma"
Higham, James E.S.; Cohen, Scott A.	2011	Canary in the coalmine: Norwegian attitudes towards climate change and extreme long-haul air travel to Aotearoa/New Zealand
Higham, James; Cohen, Scott A.; Cavaliere, Christina T.; Reis, Arianne; Finkler, Wiebke	2016	Climate change, tourist air travel and radical emissions reduction
Higham, James; Reis, Arianne; Cohen, Scott A.	2015	Australian climate concern and the 'attitude–behaviour gap'
Hinnen, Gieri; Hille, Stefanie Lena; Wittmer, Andreas	2017	Willingness to Pay for Green Products in Air Travel: Ready for Take-Off?
Jou, Rong-Chang; Chen, Tzu-Ying	2015	Willingness to Pay of Air Passengers for Carbon-Offset
Khand, Purna Bahadur	2019	Air Traveler's Willingness to Pay to Offset Their CO_2 Emission in Pokhara

Kim, Yohan; Yun, Sunyoung; Lee, Joosung	2014	Can Companies Induce Sustainable Consumption? The Impact of Knowledge and Social Embeddedness on Airline Sustainability Programs in the U.S
Kroesen, Maarten	2013	Exploring people's viewpoints on air travel and climate change: understanding inconsistencies
Lu, Jin-Long; Shon, Zhang Yi	2012	Exploring airline passengers' willingness to pay for carbon offsets
Lu, Jin-Long; Wang, Chiu-Yi	2018	Investigating the impacts of air travellers' environmental knowledge on attitudes toward carbon offsetting and willingness to mitigate the environmental impacts of aviation
MacKerron, George J.; Egerton, Catrin; Gaskell, Christopher; Parpia, Aimie; Mourato, Susana	2009	Willingness to pay for carbon offset certification and co-benefits among (high-)flying young adults in the UK
Mair, Judith	2011	Exploring air travellers' voluntary carbon-offsetting behaviour
McDonald, Seonaidh; Oates, Caroline J.; Thyne, Maree; Timmis, Andrew J.; Carlile, Claire	2015	Flying in the face of environmental concern: why green consumers continue to fly
McKercher, Bob; Prideaux, Bruce; Cheung, Catherine; Law, Rob	2010	Achieving voluntary reductions in the carbon footprint of tourism and climate change
McLennan, Char-lee J.; Becken, Susanne; Battye, Rod; So, Kevin Kam Fung	2014	Voluntary carbon offsetting: Who does it?
Ritchie, Brent W.; Sie, Lintje; Gössling, Stefan; Dwyer, Larry	2020	Effects of climate change policies on aviation carbon offsetting: a three-year panel study
Schwirplies, Claudia; Dütschke, Elisabeth; Schleich, Joachim; Ziegler, Andreas	2019	The willingness to offset CO_2 emissions from traveling: Findings from discrete choice experiments with different framings
Segerstedt, Anna; Grote, Ulrike	2016	Increasing adoption of voluntary carbon offsets among tourists
Shaari, Nur Fatihah; Abdul-Rahim, Abdul Samad; Afandi, Syamsul Herman Mohammad	2020	Are Malaysian airline passengers willing to pay to offset carbon emissions?

Shrivastava, Neharika; Sharma, Vandna; Chaklader, Barnali	2019	A study to assess impact of carbon credit trading into costs and prices of different goods and services - a study from the airline industry
Sonnenschein, Jonas; Mundaca, Luis	2019	Is one carbon price enough? Assessing the effects of payment vehicle choice on willingness to pay in Sweden
Thunström, Linda; van't Veld, Klaas; F. Shogren, Jason; Nordström, Jonas	2014	On strategic ignorance of environmental harm and social norms
Tyers, Roger	2018	Nudging the jetset to offset: voluntary carbon offsetting and the limits to nudging
van Birgelen, Marcel; Semeijn, Janjaap; Behrens, Pia	2011	Explaining pro-environment consumer behavior in air travel
Zhang, Beile; Ritchie, Brent; Mair, Judith; Driml, Sally	2019	Can message framings influence air passengers' perceived credibility of aviation voluntary carbon offsetting messages?
Zhang, Beile; Ritchie, Brent; Mair, Judith; Driml, Sally	2019	Is the Airline Trustworthy? The Impact of Source Credibility on Voluntary Carbon Offsetting