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„How can we make environmentally harmful actions costly without generating social inequality?“

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Abstract

This thesis aims at finding a scheme to reduce private aviation emissions. The proposed idea is a so-called resource account, where every citizen owns an account with a certain amount resource points per year per person, which then get subtracted when conducting an action that emits harmful emissions, (e.g. flying). It is still possible to emit more once this budget is exhausted, however only by paying additional taxes per resource point. An additional idea introduces a trading scheme, making it possible to buy and sell these points. To analyze the acceptance and to find the scheme (tax or trading) and budget (amount of kg CO_2e) that seems to be the most fair and effective at the same time, a survey was conducted. Whilst no conclusion can be drawn about the best scheme, both seem to be equally accepted, the budgets could be distinguished further. The middle budget of 500 kg CO_2e seems to be the fairest and most effective option, considering all aspects. The regression analysis revealed that the willingness to reduce emissions (e.g. by flying less or compensating flights) indicates a preference towards a lower budget. The opposite holds when having family or work as primary reason for flying. No conclusion could be drawn on the influence of individual demographics.

Kurzfassung

Das Ziel dieser Arbeit besteht darin, ein System zur Reduzierung der Emissionen des privaten Luftverkehrs zu entwickeln. Die hierbei entstandene Idee ist ein sogenanntes Ressourcenkonto, bei dem jede:r Bürger:in ein bestimmtes Budget an Ressourcenpunkten pro Jahr und Person hat. Diese Punkte werden abgezogen, wenn schädliche Emissionen verursacht werden, z.B. durch Fliegen. Ist das Budget aufgebraucht, besteht die Möglichkeit weitere Ressourcenpunkte durch die Zahlung zusätzlicher Steuern zu erlangen. Eine weitere Idee ist die Einführung eines Handelssystems, das den Kauf und Verkauf dieser Punkte ermöglicht. Um die Akzeptanz und Wirksamkeit dieser Idee zu analysieren und das System (Steuer oder Handel) und das Budget (Menge an kg CO2e) zu finden, das am gerechtesten und gleichzeitig am wirksamsten erscheint, wurde eine Umfrage durchgeführt. Während keine Schlussfolgerung über das beste System gezogen werden kann, da beide gleichermaßen akzeptiert zu sein scheinen, konnten die Budgets weiter unterschieden werden. Das mittlere Budget von 500 kg CO2e scheint, unter Berücksichtigung aller Aspekte, die fairste und effektivste Option zu sein. Die Regressionsanalyse ergab, dass die Bereitschaft, Emissionen zu reduzieren (z.B. durch Reduzierung der eigenen Flüge oder Kompensationszahlungen), eine Präferenz für ein niedrigeres Budget darstellt. Gegenteiliges gilt, wenn der primäre Grund für eine Flugreise die Familie oder der Beruf ist. Es konnten keine Rückschlüsse auf den Einfluss individueller demografischer Merkmale gezogen werden.

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Introduction

How can we persuade our society to care more for the environment we live in? A question not only I have asked myself quite frequently over the last years, nonetheless since I started environmental classes in university. When I observe my social environment of young, rather well-educated people, most realize that they must actively seek solutions to the climate crisis and are doing what they can to not harm the environment even further. Unfortunately, this section of society despite the efforts of some, is simply too insignificant to achieve the changes we need. And without meaningful changes, the outlook for our planet is not encouraging. To achieve these changes, the general populace as a whole must work towards the protection of our environment.

The biggest challenge of our time is how to implement these changes in time to prevent the looming catastrophic effects of climate change. We could of course simply denote taxes on everything considered environmentally harmful. However, after five years of studying economics, it has come clear this cannot be the solution, as this in turn would generate a degree of inequality which could create such massive social upheavals that it could threaten the very structure of our society. What then to do? Inaction is no solution, but neither is action that could upend the social fabric of our society and risk even more harm to our environment.

The question I am asking myself within this thesis therefore is: How can we make environmentally harmful actions "costly" without generating social inequality?

Europe has come to a point where it can no longer downplay global warming, the resulting consequences are just too severe. The solution to this problem was supposed to be the Paris Agreement, an international treaty on climate change adopted in 2015 with massive media coverage and public attention. The goal is ambitious, net-zero emissions by 2050 (United Nations, 2015). To achieve this the aviation industry, as part of a sector that is actually still increasing its emissions, cannot be excluded from this plan. It therefore joined the EU's Emissions Trading System in 2012, as well as an emission reduction scheme for international flights starting in 2021 (European Commission, n.d.a).

However, there are two major problems with this, firstly the 352-page long study on behalf of the European Commission stating that these two schemes will not be sufficient to meet the aims of the Paris Agreement (ICF Consulting, 2020), and secondly, the fact that all these measurements target airlines, none actually target the individuals using these services. Although the actual emitters are the airlines, it still remains up to each individual passenger to substitute this emission intensive way of transport with a less polluting alternative. A demand reduction, if

sufficiently high, could lead to a supply change by eighter reduction or substitution, which in turn would lead to a subsequent decrease in harmful emissions. The prime example for this economic effect is the meat and fish industry. Their products are increasing getting substituted by plant-based products, after years of declining animal-based nutrition (Graca, et al., 2019).

This is where the idea of the resource account (RA) steps in. Every citizen would own an account with a certain number of GHG emissions (called resource points) per year per person, which then get subtracted when conducting an action that emits harmful emissions, (e.g. flying). In the case of air travel the RA consists not of points, but of a CO_2e amount (budget). It would still be possible to emit more once this budget is exhausted, however only by paying additional taxes per resource point. In addition, the idea of the RA is taken even further by implementing a trading scheme, making it possible to buy and sell these points. This is the central idea behind this thesis, to not just impose a fixed tax per flight, eventually making it a luxury good, but finding a way to decrease harmful emissions through an increase in prices in a socially acceptable manner.

The general idea of such an account was first mentioned in a short essay by Hillman (Hillman, 1998), and later developed further by Hillman and Fawcett (Hillman & Fawcett, 2004). Their premise is a certain carbon allowance per adult for household energy and personal transport, which can then be traded if not needed. It was even briefly discussed in UK politics in 2008, however declared as ‘an idea currently ahead of its time’ (Fawcett, 2010b).
There is still an ongoing debate in research about whether such an account would be acceptable, fair, and effective. What can be agreed upon however is that more research on this topic needs to be conducted. This is what this thesis will be doing, by analyzing the acceptability of such a scheme on flights with the help of a survey. The aim of this thesis is to gain further insight into whether the resource account is an acceptable option for reducing environmentally harmful actions, as flying, by making such actions costly without generating social inequality.

This was done by analyzing the 139 fully answered questionnaires to find the scheme (tax or trading) and budget (amount of kg CO_2e) that seems to be the most fair and effective at the same time.
Whilst no conclusion can be drawn about the best scheme, both tax and trading seem to be equally accepted, the budgets could be distinguished further. Whilst, unsurprisingly, the highest budget of 2,500 kg CO_2e was the most popular one, the middle budget of 500 kg CO_2e seems

to be the fairest and most effective option. Both these budgets are however still significantly above the level that would be needed to reach the Paris Agreement objective, which could only be reached with a maximum of 100 kg CO_2e. This budget, unsurprisingly, was the least popular. Even revealing the fact that this is the amount needed for sufficient emission reduction did not change the answer behavior.
The regression analysis revealed which variables significantly influenced the outcome. Especially the willingness variables (e.g. willingness to fly less, compensate, restrict the total amount of flights) indicated a preference for a lower budget. The opposite holds when having family or work as primary reason for flying. Whilst individual demographics also affected the outcome, the pattern seemed rather random, and no conclusion could be drawn.

Firstly, the *current regulations* chapter explains the already existing measurements in the aviation sector, followed by the *literature* where not only the resource account idea is discussed scientifically, but also various ideas and aspects, such as the implementation of a fixed passenger tax or economic consequences of substitution and elasticity effects. To thoroughly understand the underlying idea, the chapter *resource account* will explain it in detail, also with the help of an *example equation*.
After this theoretical background, the *survey* itself and its *outcome* will be discussed, forming the main part of this thesis. For a better overview, the outcome is divided into the four main parts of the survey, followed by an outcome summary which then argues which budget and scenario performed the best. The *Conclusion* will look at possible *extensions* and suggestions for further research.

Current regulations

In order to stay in line with the Paris Agreement's objective of keeping global warming significantly below 2°C, ideally even below 1.5°C (United Nations, 2015), the EU has set the target of achieving climate neutrality by 2050, having net-zero emissions from 2050 onwards. To do so the European Commission set a new intermediate goal in 2021 of at least 55% net reduction in greenhouse gas (GHG) emissions by 2030 compared to 1990 (European Commission, n.d.a). Within this objective, the aviation industry plays a significant role, as this sectors' emissions have increased by more than 50% from 1990 onwards. The transport industry in general is the only sector that failed to reduce its emissions compared to 1990, in fact, it even experienced a 20% increase within this timeframe (European Commission, n.d.b). In response, aviation emissions have been integrated into the EU's Emissions Trading System (ETS) in 2012, meaning they must obtain an allowance for each ton of CO_2 generated. It originally intended to cover all flights starting or landing within the European Economic Area (EEA), however, due to protests from non-EU airlines it got reduced to only intra-EEA flights. The EEA now includes all EU Member States, Iceland, Liechtenstein, and Norway. Additionally, flights to Switzerland and Great Britain are included as well, however not within or from these countries, as they therefore implemented their own ETS System. Being part of the ETS scheme, airlines must have obtained an emission allowance for each flight. (European Commission, n.d.a). 82% of the allowances are allocated at no cost, 3% are set aside for a special reserve of new entrants and 15% are auctioned. However, as a result of this fairly generous number of free allowances, the ETS regulation failed to have the intended effect of increasing flight prices or reducing the number of emissions, as airlines did not have to bare high costs for allowances so far. A revised plan now seeks to reduce the number of allowances, which was at 24.5 million in 2021, with an increased linear reduction of 2,2% annually (European Commission, n.d.c).

In addition, and partly as response, to the EU-developed ETS trading scheme, the International Civil Aviation Organization (ICAO) has introduced a scheme for international flights, named Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Its goal is to keep aviation emissions at the 2020 level, by requiring airlines to monitor and offset all CO_2 emissions from international flights above this 2020 level. The pilot phase began in 2021, with the obligatory phase set to start in 2027. It has to be noted that participation during this pilot phase is only voluntary, so whilst all European countries do participate, many others decided not to (European Commission, n.d.a).

Under these two systems, all flights within the EU as well as international, should be covered. However one major drawback that needs to be considered when mentioning aviation emissions, is the fact that air travel not only generates CO_2, but also other pollutants as nitrogen oxides, water vapor, sulphate, as well as soot particles at high altitudes. They even account for approximately 2/3 of the total flight emissions. ETS and CORSIA do not account for these non-CO_2 emissions, thus generating a false narrative between the covered and the actual amount of emissions generated by aviation (European Commission, n.d.b).

This is not the only obstacle regarding the schemes. A study on behalf of the European Commission assessing the economic, social, and environmental impacts of different EU policy options for ETS and CORSIA, as well as the ambitions of the CORSIA goal, its environmental integrity, and various other aspects, came to a rather negative result. The study, stretching over 352 pages, concluded that the CORSIA scheme is not compatible with the goal of climate neutrality by 2050, as it only plans on reducing the growth of emissions after 2020, which will not be sufficient to reach the 2050 goal. The study also states that CORSIA does not give airlines sufficient incentives for CO_2 savings, the compensation mechanism is not transparent enough, and it could lead to so-called double accounting as the offsetting mechanism could lead companies to sell offsetting projects originally commissioned as part of their countries' climate change mitigation policy to airlines, who then use it for the CORSIA offsetting, leading to a double accounting of the compensated emissions without actually having additional compensation mechanisms in place. This does not even have to be up to the bad will of companies or countries, according to the authors it is just not feasible to document and audit every project. It is also not clear how long these compensation projects must stay in force, a forest for example could be bought as an offset measure only to be sold or deforested a few years later, thus negating the effects of the initially desired long-lasting compensation (ICF Consulting, 2020). With ever changing political goals through new elections and the parties in power, this is not an unrealistic scenario. This devastating outcome might also be the reason why the report was initially held back for months by the European Commission (Götze, 2021).
This result, both politically and scientifically, makes it clear that the current systems are not generating enough emission reduction, thus making it imperative to find additional solutions for emission, specifically aviation emission reduction.

Recent research also brought to light that so far, only "macroeconomic" measurements targeting airlines have been implemented, with voluntary compensation being the only "microeconomic"

measurement on an individual level. Researchers also came to the same conclusion, of having individual level measurements as supplements to existing policies, not substitutions (Zhang & Feng, 2022). This is where the individual resource account comes into play. It would not be a substitute for the existing systems, but an addition that does not interfere with the ETS or COR-SIA system.

Literature

Larsson et al. (2019) examined national as well as international aviation policies with regard to their political as well as environmental effectiveness. Whilst they also conclude that the ETS and CORSIA schemes are not sufficient enough to reach the Paris Agreement objective, a national, distance-based air passenger tax could in fact reduce the demand for air travel, given a substantially higher taxation amount than the one currently in place in European countries. When examining the impacts of the implementation of such a taxation scheme in Germany in 2011, the number of aircraft passengers did reduce by 8 to 10.5% in the first year, however not having any effects the years after, supporting the call for higher taxes (Helmers & van der Werf, 2022). This is also in line with Sweden and Finland, where overall passenger numbers did not decrease after the implementation of the aviation tax (Warras, 2020). There are, however, also results that point in the other direction. Collet et al. (2022) for example found that a one euro increase in the European air passenger tax leads to a 0.3% decrease in the passenger number in the short-term, and a 1.5% decrease in the long-term. It however must be noted that these results are strongly heterogenous, and more research needs to be done to better understand these effects (Collet et al., 2022).

What is however crucial is to figure out whether the net effect is positive or negative. It is still possible to have a negative net effect on emissions even when the number of passengers goes up, this occurs when offsetting overcompensate for higher emissions steaming from higher passenger numbers. So just examining the change it passenger numbers is not sufficient enough.

Also, for a passenger tax to work effectively, many countries must take part to not have a substitution effect on countries with less or even no taxation scheme in place, as seen after the introduction of the tax in Germany (Borbely, 2019).

A more difficult substitution effect to evaluate is from flights to cars or trains. Whilst it reduces the amount of aviation as well as overall transport emissions, the negative monetary consequences for airlines, lower tax incomes for states, and especially the risk of public discontent due to higher taxes leading to political instability should not be disregarded. The prime example being the ‘yellow vest’ protests in France as a result of increased fuel taxes in 2018. A possible way to avoid this is an increasing passenger tax level tied to the number of individual flights per year per passenger, which could be a more acceptable solution for the general public (Larsson et al., 2019). These findings have been taken into consideration for the resource account, ensuring a certain amount of lower taxed flights per year.

There is of course a difference in how passengers react to various taxation levels. A review on price elasticities based on previous scholarly studies and new econometric estimates commissioned by the International Air Transport Association (IATA) showed an average price elasticity in the passenger aviation market of −0.8. Specifically, they found the elasticity to be lower for business trips, higher for private trips, lower for longer flights and higher for shorter flights. They also found a positive income elasticity between +1 and +2 (InterVISTAS, 2007).
Further aspects in favor of a tax compared to trading scheme are an easier comprehension, which could lead to a higher rate of acceptability within the public, a simpler as well as cheaper implementation and the generation of a tax revenue which could be used in various ways (Bristow et al., 2010).
An interesting idea is the "a free ride" project, which uses the same foundation as the resource account with tax, calling it frequent flyer levy. They demand one tax free return flight each year, not specifying how long that flight might be, and an increasing tax per flight for every additional flight within the same year. The tax would then be used to support greener alternatives to flying. It seems however this project is no longer active, as the last publication was in April 2020 (A free ride, n.d.).

Increasingly, studies focus on the idea of the resource account with trading, often known as private carbon trading (PCT). This idea was initiated in a short essay by Hillman (Hillman, 1998) and then further developed by Hillman and Fawcett (Hillman & Fawcett, 2004). Their premise is a certain carbon allowance per adult for household energy and personal transport, which can then be traded if not needed. Now, 25 years after the first paper, there is a wide range of model designs, differentiating all kinds of parameters (emissions, citizens, thresholds, etc.) and implementation methods.
It was even briefly discussed in UK politics in 2008, however declared as 'an idea currently ahead of its time'. The key concerns at that time were a lack of public acceptance and high implementation, as well as operating costs (Fawcett, 2010b). In 2012 Fawcett again evaluated the possibility of establishing a PCT in the UK and found that whilst operating costs would in fact be higher than comparable taxation policies, most research showed PCT to be at least as socially acceptable as other taxation policies and even higher acceptability rates than a carbon tax. The conclusion however again stated that it was too early to actually implement it, as there was neither a policy design, nor enough research done to prove the efficiency and acceptability of such an idea (Fawcett, 2012), which was also in line with other research outcomes (Starkey,

2012b). Further challenges to be considered are, amongst others, technical challenges, economic feasibility, adverse distributional effects, as well as various political restrictions (Fawcett & Parag, 2014) (Fawcett & Parag, 2010) (Bristow et al., 2010) (Zhang & Feng, 2022) (von Wright et al., 2022).

Lahti in Finland went even further than the UK and set up a pilot PCT for urban transport with the help of a phone app[1]. Besides also stating that more research is needed, they witnessed a redistribution effect of the PCT. Within their sample transport emissions were lower for people with a lower average income, leading to "unused emissions" that could then be traded and thereby generating an additional income. The intensity of this redistribution effect expectedly highly depended on the chosen parameters for the cap, carbon price and emission allocation and stresses the importance of further research in this field. (Uusitalo et al., 2021).
Examining the scope of a PCT, Fawcett found that an implementation at the national (state) rather than EU (US) level seems more feasible, at least to begin with, due to differences in national carbon emissions, targets, policies in place, and concerns about equity and distributional effects of the policy. She however also states that a national implementation could lead to the already mentioned substitution effects with cross-border buying of fuels and substituting national with international hubs for long-distance flights, claiming that researchers so far may not have paid sufficient attention to these cross-border substitution effects (Fawcett, 2010a). This does not seem to have changed over the years, to my knowledge no experiment focused explicitly on activities that could have these effects (e.g. flights), rather on other means of transport or household generated emissions (Zhang & Feng, 2022) (Uusitalo et al., 2021) (von Wright et al., 2022) (Raux et al., 2015) (Starkey, 2012a) (Starkey, 2012b). Bristow et al. did include flights in two of their models but failed to find a significant difference to the models without air travel (Bristow et al., 2010). Again, they did not explicitly test for flights, it was merely an addition to domestic energy and car use.

A distinction often found in the literature is between the RA with trading (PCT) and a simple carbon tax (CT) where the PCT only introduces a tax after a certain emission budget is used up, whilst the CT is a simple tax on various products with the exact details depending on the experiment. The results on the PCT are quite promising and state that, after examining various public surveys on its acceptability, support for PCT is not obviously lower than for alternative instruments (Starkey, 2012b) and that PCT and a CT are considered equally fair (Starkey,

[1] When reding these results it should also be noted that the number of participants was only 89 in this first pilot.

2012a). The same goes for the effectiveness of changing travel behavior, where no significant difference between the two schemes could be found (Raux et al., 2015) and that it depends on the detailed structure and implementation, as otherwise there is no preferred scenario (Bristow et al., 2010).

At the end of the day there is still an ongoing debate in research about which scheme is more acceptable, fair and effective. What they can agree upon is that more research needs to be conducted. As to my knowledge no paper focuses exclusively on flights, so the aim of this paper is to fill this gap.

Resource account

The basic idea is an account with a certain number of GHG emissions (called resource points) per year per person, which then get subtracted when conducting an action that emits harmful GHG emissions, (e.g. buying a car, building real estate, or flying). Once these points are used up it is still possible to emit more, however only by paying taxes per resource point. In addition, one may take the idea of the RA even further by implementing a trading scheme, making it possible to buy and sell these points.

This account can be used for any kind of action that produces emissions, however for the time being I will restrict it to flights, as they are a major part of private emission generation, widely used in society by all groups of people and there is a wide range of data to draw from. In this case the resource account (RA) consists not of points, but of a CO_2e amount (budget). As mentioned in chapter *Status Quo* the schemes currently in place merely target CO_2, which actually only account for one third of the GHG emissions emitted by air travel. To avoid replicating this bias and for better understandability as well as transparency, the RA budget does include all GHG emissions, converted into CO_2 equivalents (CO_2e). This is an established approach within this field and therefore also implemented by atmosfair, an emission calculator and compensation provider, which was used to calculate the example routes for the survey[2] (atmosfair , 2021).

The baseline hypothesis is that the tax or trading system implemented after using up the "free" emissions will increase the cost of air travel and thus decrease the demand of it, leading to less emissions in the long run. However, the aim behind this idea is to not only reduce the overall emissions, but do so in a socially fair way, by transferring more costs to the high emitters.

The RA with tax does not have a maximum number of flights or emissions to be produced per year, merely a fixed threshold above which taxes must be paid which will then be used for environmental purposes, e.g. offsetting emissions or investing in new technologies. Both the threshold and tax amount will vary according to the chosen model to find out which parameters would most likely be accepted.

The RA with trading, derived from the trading scheme of industrial CO_2 certificates, does have a fixed number of emissions to be emitted per year which is then evenly divided among the populace. It is then possible to trade these emission allowances with the price being determined

[2] Atmosfair explains it in the following way: „ Based on the current research results, a factor of 3 for non-CO_2 emissions on CO_2 emissions is obtained for the consideration of non-CO_2. […] Consequently, the atmosfair emissions calculator multiplies all CO_2 emissions that occur at altitudes above 9 kilometres by a factor of 3 to reflect the climate impact of the flight in CO_2." (atmosfair , 2021)

by the market, as it is also the case with the industrial certificates. Again, the number of emissions and the price per allowance, as it won't be possible to reproduce a market scenario, will vary according to the chosen model to find the most acceptable parameters.

Environmentally speaking the trading scenario would be more beneficial as the number of emitted emissions can be fixed, assuming the responsible governments use it in a sustainable way. This is a crucial steering effect the tax scenario does not have.
Socially speaking the trading scenario can have two effects. Eighter it could have a positive redistribution effect, based on the hypothesis that people who fly more (high emitters) and therefore have to buy emission points, also own more money on average, whilst people with less income fly less, therefore selling their emission points. These two effects could lead to an overall socially desirable redistribution from higher to lower income households. However, on the other hand this could increase social inequality by forcing lower income households to sell their points to generate an additional income, making air travel less accessible to the broad public. This would then be counter effective as the idea of the RA is to decrease monetary and social inequality by allowing everyone to fly for a decent price. If this effect were to happen, the RA would fail and have the same social effect as a simple fixed tax per flight[3].
The price for the tax and certificates used in the survey is 1€ per 20 kg CO_2e. This price is derived from the current carbon price in Europe which, at the time the survey was conducted in June 2022, was around 84€ per ton, leading to a kilogram price of 8.4 cents. For simplicity reasons I worked with 5 cents per kilogram. Between May and June the price varied between 78€ and 92€, making 5 cents an adequate average (Carbon Credits, n.d.). This is also the amount Sonnenschein and Smedby found to be the average willingness to pay on air ticket surcharge for a short distance flight (Sonnenschein & Smedby, 2019).

[3] For transparency it should be mentioned that this effect was supposed to be measured in the survey by asking: *Do you think that you would be a net buyer or seller of certificates?*
However, the answer possibilities given were the same as for the other questions, from not at all (1) to definitely (5).
As the answer possibilities unfortunately did not match the question, the answer could not be evaluated and no statement regarding the social effect can be made.

Example equation

To further explain this idea, I set up an example. The emission budget is at 500 kg CO_2e, so one can fly from Vienna to Berlin and back (300 kg CO_2e) (atmosfair, n.d.) without paying any additional tax, as it is within these 500 kg CO_2e. If, however, one wants to fly to New York and back (3.500 kg CO_2e) (atmosfair, n.d.), a tax of 150€ on the remaining 3,000 kg CO_2e needs to be paid.

> *Vienna to Berlin*: 300 kg CO_2e --> no tax (500-300 = 200 kg CO_2e left)
> *Vienna to New York*: 3.500 kg CO_2e --> 150€ tax (500-3.500 = -3,000 kg CO_2e --> 3,000/20 = 150€ tax)

The same goes for the trading scenario. The emission budget is again at 500 kg CO_2e, so when flying from Vienna to Berlin and back one has 200 kg CO_2e left to sell, generating a surplus of 10€. When flying to New York and back, however, 3,000 additional points are needed, which can be bought for a price of 150€.

> *Vienna to Berlin*: 300 kg CO_2e --> points sold: 200 for 10€ (500-300 = 200 kg CO_2e --> 200/20 = 10€ "profit")
> *Vienna to New York*: 3,500 kg CO_2e --> points needed: 3,000 for 150€ (500-3,500 = -3,000 kg CO_2e --> 3,000/20 = 150€ "cost")

Survey

The survey is structured into four parts. Whilst the first three form the actual survey, the last one consists of general questions on demographics and flight behavior, needed for regression analyses.

Status Quo

The first set of questions present four different scenarios on how to reduce flight emissions. These options are the ETS and CORSIA scheme, a fixed tax per flight of 50€, and the resource account (RA). To prevent a bias towards already existing schemes, it is not mentioned that ETS and CORSIA have already been implemented. The intention behind this first part is to measure how the RA performs compared to the other ideas and whether this is an alternative the general populace would accept. For each of the four scenarios the same five questions were asked, see Figure 1.

The hypothesis for this first part is that whilst people will accept all options, they may have a slight tendency towards ETS and CORSIA, as with these airlines instead of individuals appear to bear the additional costs. However, a significant tendency towards one of the scenarios is not expected, which is also the preferred outcome to know the RA can compete with the already existing ideas.

Resource Account

The following two sets of questions focus on the resource account. This forms the main part of the survey and aims at finding the best fitting parameters (tax or trading and an emission budget) for the resource account.

The participants are given three different emission budgets (100; 500; 2,500 kg CO_2e) as well as two different net incomes (1,000€ and 3,000€). The reasoning for specifying incomes is to have comparable income data, as the number of participants is too low to generate a representative sample per income range. They are additionally asked which of the three budgets, under each income, they find the most fair and effective at the same time. So, all in all, the participants are given three emission budgets and two incomes, answering various questions within these six variations.

After having been asked this for the tax scenario, they will again be asked the same for the trading scenario. As mentioned before, the price was set at 1€ per 20 kg CO_2e, which was approximately the price per certificate at the time of the survey (see chapter *Resource account*).

In the trading scenario, it is explained that this is only the starting price and that prices will change according to the market situation.
The hypothesis is that the most accepted budget will be the highest one, 2,500 kg CO_2e, which will also be the most likely to be implemented within the EU as well as worldwide.
However, it is also expected that people, when asked what they find the most effective, will choose a lower budget as it is common knowledge that a drastic cut in emissions is needed to prevent further global warming.
To account for both effects, the middle budget of 500 kg CO_2e is anticipated to be chosen as the most fair and effective option at the same time.
The difference between the tax and the trading ratio is another aspect to be examined. According to the available literature no significant preferences can be seen (see chapter *literature*), which is therefore also the hypothesis for this survey.

Real scenario & comparison

After having answered these questions, it will be revealed which emission budget would be needed to reach the Paris Agreement goal (100 kg CO_2e). With this in mind, participants are again asked the same five questions for this budget and both incomes. This part should analyze whether giving additional information leads to differences in their answering behavior. Would this be the case and people would rather choose the 100 kg CO_2e solely by granting this additional information, a so called "information nudge" effect could potentially be found, unknowingly leading people into doing as directed (preferring 100 kg CO_2e in this case). Even though this would be an important finding for setting a policy strategy, it is doubtful how big this effect will actually be.
It is expected that this additional information will have an influence and people would be more willing to accept the lower budget, indifferent to the given income, however it is uncertain whether this will make a significant difference. The average answers for asking whether this can be implemented within the EU and worldwide are not expected to change. The opposite holds for whether this is fair for individuals, as it is now not a randomly but scientifically chosen budget, therefore increasing the impression of fairness.
Participants will additionally be asked to compare the ideas from the first part (ETS, CORSIA, fixed tax, RA tax, RA trading), as well as only the two RA ideas (tax, trading) to evaluate what they find the most fair and effective at the same time. The hypotheses are similar to the first part, with ETS and CORSIA being favored, as airlines instead of individuals bear the costs. For

the two RA ideas there is no significant preference expected, as this would be in line with the literature and there are no indications to suggest otherwise.

Demographics

Lastly, two sets of questions were asked, the first related to flight behavior (amount, willingness to reduce, compensation & purpose of flights) and the second related to demographics (thoughts on climate change, gender, age, income, employment, education). These answers will be used in the regression analysis, the statistical approach of which will be explained in the according chapter.

The hypothesis is that individuals who fly less are more aware of the negative impacts of flying and are therefore more likely to express a willingness to reduce their own flight emissions and have concerns about global warming. These aspects –willingness to reduce emissions and concerns about global warming - are expected to make individuals prefer the lower budget as they are more aware of the consequences.

A higher amount of yearly (domestic and international) flights, as well as work as primary reason for flying are expected to lead to a preference of a higher budget.

Demographics are not expected to play a crucial role, as the sample population is not representative enough of the different characteristics. Also, as these variables are potentially correlated, their expressive power may be limited.

Outcome

The survey was conducted with the help of soSci, a free website for students from the University of Vienna. In ran for 20 days with a total number of 147 participants out of whom 139 filled out the full survey that were then used for the following analysis. For illustrative reasons the graphs were conducted in Excel, whilst the statistical analysis was done with RStudio.
The sample population is primarily male (64%), between 20 and 30 years (78%), with a high school diploma (Matura) as highest degree (50%), is still studying (65%) and has a net monthly income below 1,000€ (42%) or between 1,000 to 2.000€ (37%). A summary statistic can be found in Table 2.
An illustration of the online survey can be seen in Appendix A.

To evaluate the results both the average answer (mean), but also the most common one (mode) was used. This is commonly done for survey results and might sometimes be the more interesting value, being more robust against outliers (Fink, 2017). To see if the evaluation method influences the outcome, differences between the two methods were always analyzed. The standard errors got analyzed as well and depicted graphically in the figures and tables. As they were however always within an acceptable range, they did not get analyzed further (exception: chapter flight behavior).

The same holds for the sample size, the first analysis was done with all 139 answers. In the second stage, a subsample was formed according to the malus value, with all malus' over 100 getting excluded. The parameter shows how fast participants answer, indicating that they might not have read the questions thoroughly and have answered randomly if the malus value is very high. This subset excludes 19 of the 139 samples, leaving exactly 120 to evaluate.
There are also other possible parameters to examine for forming a subset. Possibilities could be demographic outliers such as very low/high incomes. This was however not the case for this survey as every demographic indicator was represented by an acceptable amount, whereby no outliers arose. Only one person under 20 would have been an outlier, which was however in any case excluded in the malus subset. Another interesting indicator is the number of flights per year, where extremely little (0) or many (10) flights could be considered outliers. However, as it is plausible to not fly at all or more than ten times, this also did not seem suitable. Also, as 49 participants on average take zero international flights per year, it would have cost almost 1/3 of the sample.

Additionally, an important argument against excluding outliers is that they were implicitly controlled for by examining the mode, which is precisely used to reduce the weight of outliers.

Crucial for the analysis is to also test for significant differences between the scenarios (e.g. tax vs. trading), but within the same question. This analysis was done with the help of the Welch two sample t-test, which tests for the hypothesis that two populations have equal means, or said differently, that the true difference in means is equal to 0. The Welch t-test, other than the student t-test, does not require equal variances, making it more robust to heteroscedasticity, whilst still having a similar power.

In the first two parts, asking about the RA and other possible options, each scenario was followed by these questions with the same five answer possibilities:

	not at all	probably not	not sure	probably yes	definitely
Do you think this is enough to reduce flight emissions by 80% by 2030?	○	○	○	○	○
Do you think this can be implemented within the EU (people accept it, bureaucracy allows it)?	○	○	○	○	○
Do you think this can be implemented worldwide (people accept it, bureaucracy allows it)?	○	○	○	○	○
Do you find this fair for airlines?	○	○	○	○	○
Do you find this fair for individuals?	○	○	○	○	○

Figure 1: Questions and answer possibilities of the questionnaire

To statistically analyze the outcome, the answer possibilities were given numbers from one (not at all) to five (definitely). For a more compact presentation of the results, the five questions will forth on be abbreviated in the following way:

Enough: Do you think this is enough to reduce flight emissions by 80% by 2030?

EU: Do you think this can be implemented within the EU (people accept it, bureaucracy allows it)?

Worldwide: Do you think this can be implemented worldwide (people accept it, bureaucracy allows it)?

Airlines: Do you find this fair for airlines?

Individuals: Do you find this fair for individuals?

Status Quo

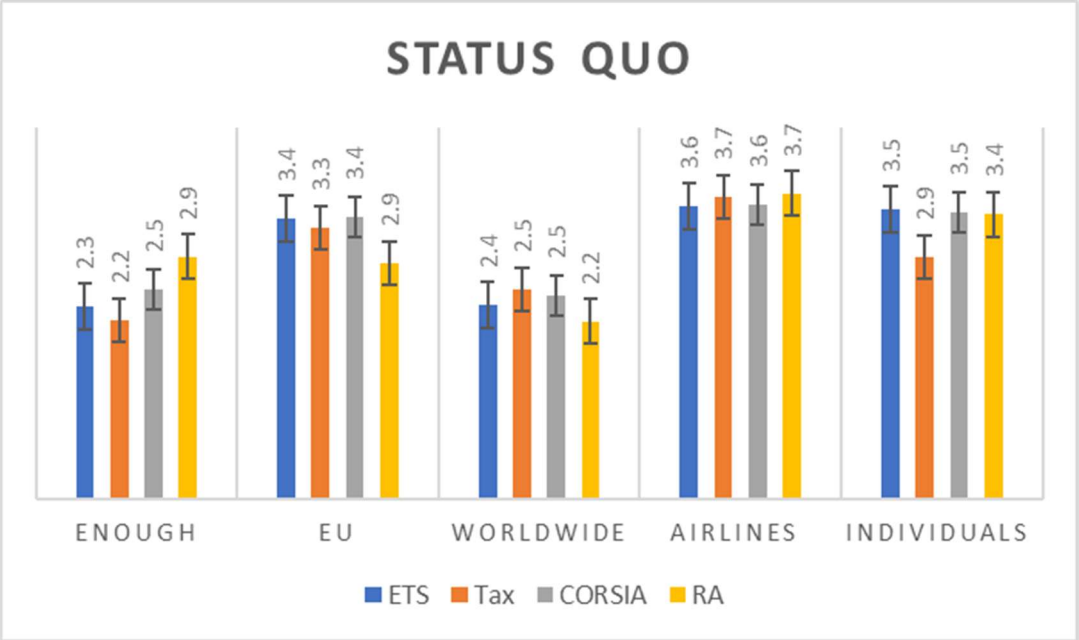


Figure 2: Outcome "Status Quo" including average answers and standard error bars. Full sample size (n=139)

As mentioned, the reasoning behind this first part was to evaluate whether the resource account, compared to the other scenarios, would even be accepted. Unsurprisingly, the range of answers is quite centered with no average below 2.2 or above 3.7 with *probably not (2)* and *probably yes (4)* forming the most common answers, indicating that all options would be accepted.

More importantly however, are the differences between the RA and the other scenarios. The following average answers differ from the answer to the RA at the 5 percent level: The RA performs significantly better compared to all other scenarios for the *Enough* question, whilst exactly the opposite holds for the *EU* question, here the RA is assessed significantly worse compared to all other scenarios, the *Worldwide* question compared to the fixed tax and CORSIA scenarios, as well as the *individual* question compared to the fixed tax.

This indicates that the RA is thought to be the best option to reach the Paris Agreement goal (*Enough*) with *probably yes (4)* as most common answer. It should however be stated that the average is still only at 2.9 (*don't know*), so in general people are not very optimistic about it. On the other hand, participants find it even less realistic for the RA to be implemented (*EU* and *Worldwide*).

These two main conclusions also hold for the subset. Additionally, the subset performs significantly worse in the *Worldwide* question compared to CORSIA, therefore performing significantly worse compared to all other options within this question.

All in all, this outcome is partly in line with the hypotheses put forward of no scenario being significantly more accepted than the others. There are only sporadic differences, no scenario is significantly preferred over another.
Overall this is a satisfying result, as the RA can keep up with the other scenarios and can therefore be seen as a realistic alternative to the already existing ETS and CORSIA schemes, as well as a fixed individual tax. This outcome was needed to justify the following thorough analysis of the RA.

Resource Account

After having found that the RA can compete with the other possible scenarios, this part now aims at finding the most suitable parameters. As this is the main focus of the survey and also the longest one, it will be divided into three parts, examining the tax and trading scenario respectively, as well as a comparison between the two. To also control for income, which plays a crucial role when choosing an emission budget, two net incomes (1,000€ or 3,000€) were specified, as mentioned earlier.

As the RA only works for individuals, the airlines question is replaced by the following:

Acceptance: Would you personally be willing to accept such a scheme?

The bars now indicate the different possible emission budgets (100; 500 or 2,500 kg CO_2e).

Tax

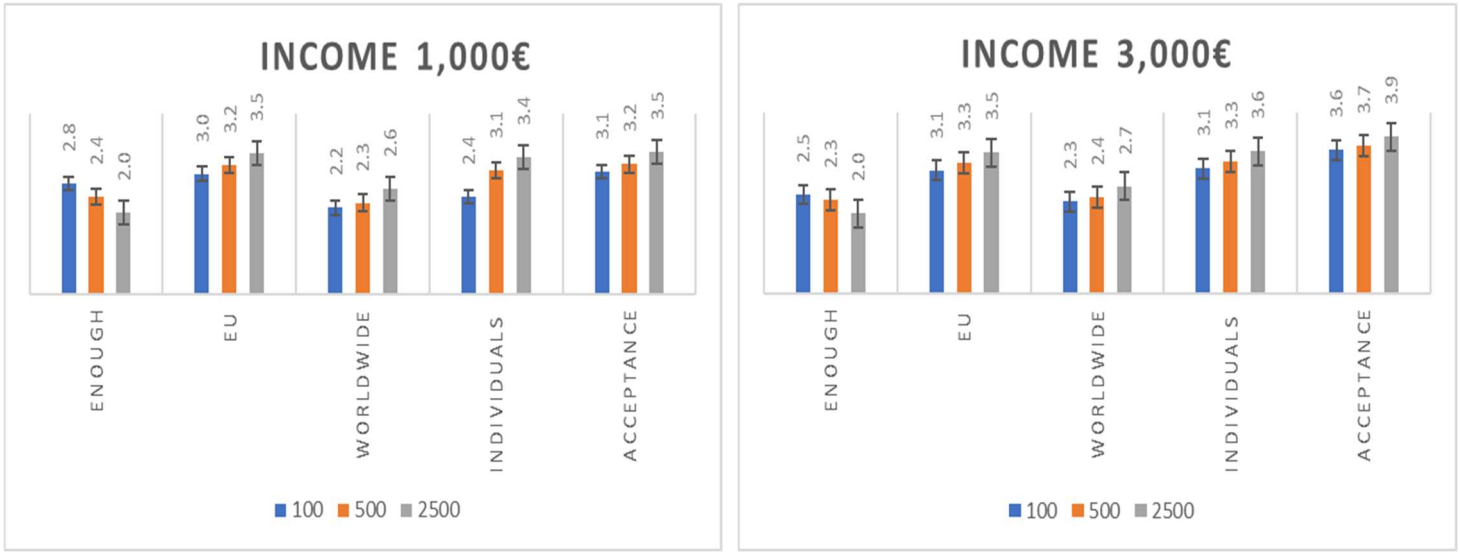


Figure 3: Outcome "Tax", respectively for an income of 1,000€ and 3,000€, iIncluding average answers and standard error bars. Full sample size (n=139)

Firstly, the average answers appear to be quite similar for the two budgets. Clearly, 2,500 kg CO_2e is thought to be the least effective to reach the 2030 emission goal (*Enough*), despite reaching the highest average answer for the other four questions. Exactly the opposite holds true for 100 kg CO_2e, and 500 kg CO_2e can be found in between. This is also the case for the Mode, which only in three out of the ten cases is not equal for all budgets.

To go into detail, significant differences for each question were identified, again at the 5% level. For 2,500 kg CO_2e this is quite significant, performing significantly better compared to the two others for three out of the five questions (*EU*, *Worldwide* and *Individuals*) (for 3,000€ only at the 10% level for *EU* and *Individuals*). It is however also considered the significantly least

effective budget to reach the 2030 goal (*Enough*), and also has 1 (not at all) instead of 2 (probably not) as most common answer here for both incomes. For the *Acceptance* question 2,500 kg CO_2e significantly outperforms 100 kg CO_2e, however not the 500 kg CO_2e (for 1,000€ at the 10% level).

Only insignificant differences between 100 and 500 kg CO_2e can be found (exception:1,000€, *Enough*) whilst sharing the most common answer for all 5 questions. So the slight preference for the 500 kg CO_2e budget should be handled with care.

All outcomes can withstand a comparison of the two incomes, as only minor statistically relevant differences can be found. When having a net income of 1,000€, people found the 100 kg CO_2e budget significantly better to reach the 2030 goal (*Enough*), which is interesting as income levels should not actually influence the ability of a budget reducing emissions. The only major difference lies within the *Acceptance* question. For each of the three budgets, people were significantly more willing to accept an RA with tax when having the higher income of 3,000€.

The survey also asked which budget one finds the most fair and effective at the same time, to test for exactly the bias conducted with the above questions. For both budgets the average (2.1 and 1.9), as well as the most common answer (2 and 1) led to 500 kg CO_2e.[4]

To summarize, the 100 kg CO_2e budget gets clearly outperformed. With the other two however no strict preference can be seen. The 2,500 kg CO_2e budget does perform better for *EU*, *Worldwide* and *Individuals* (only at the 10% level for *EU* and *Individuals* for 3,000€), whilst 500 kg CO_2e is more likely to be *enough* and is not significantly less *accepted* (only at the 10% level for 1,000€). When asked which budget is the most fair and effective at the same time, the 500 kg CO_2e budget takes the win. A difference in income does not significantly change this outcome.

The same conclusion can be drawn from the subset, with one additional significant difference between 500 and 2,500 kg CO_2e for *EU* with a 3,000€ income, which is now significant at the 5% instead of only at the 10% level.

[4] To put the numbers into context: 1 represents 100 kg CO_2e, 2 represents 500 kg CO_2e and 3 represents 2,500 kg CO_2e

Trading

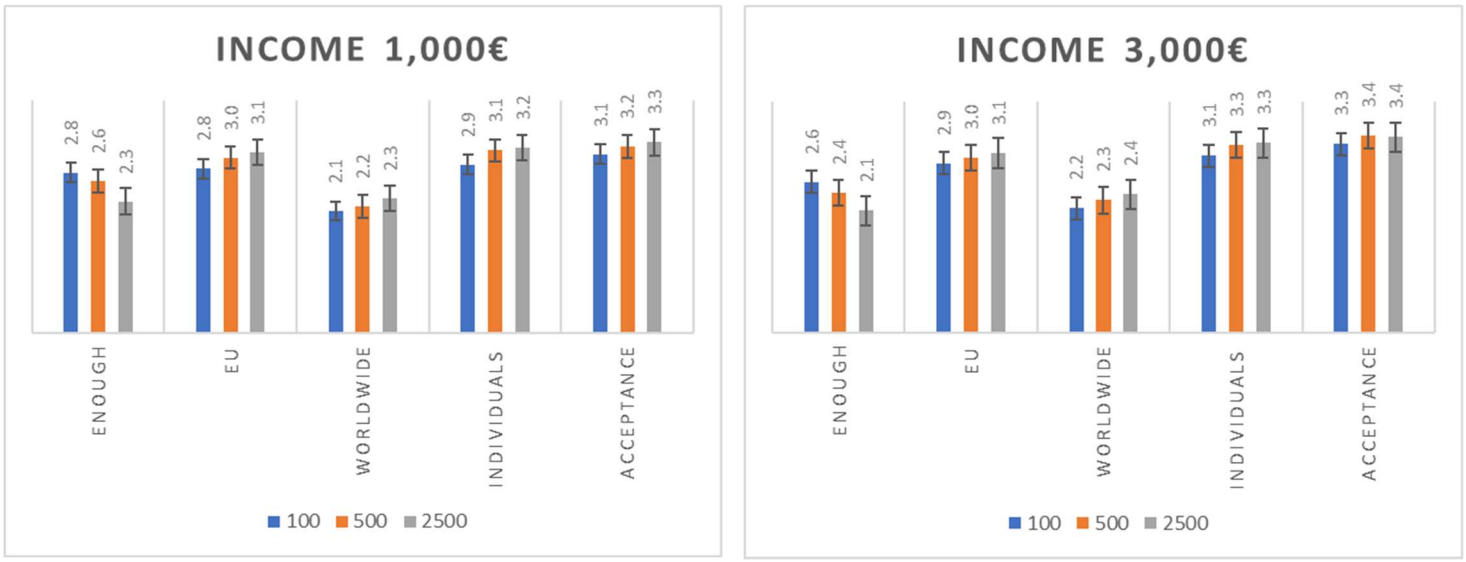


Figure 4: Outcome "Trading", respectively for an income of 1,000€ and 3,000€, iIncluding average answers and standard error bars. Full sample size (n=139)

For the RA with trading a quite similar result can be seen, with the 2,500 kg CO_2e budget found the easiest to implement (*EU* & *Worldwide*), the fairest for *individuals* and being *accepted* the most, whilst also finding it the least effective to reach the 2030 goal (*Enough*). The other two budgets also follow the RA tax scenario, with 500 kg CO_2e being preferred over the 100 kg CO_2e.

When looking at the most common answer the only difference lies within the *Worldwide* question and 1,000€ budget, where the 100 and 2,500 kg CO_2e budgets have not at all (1) as the most common answer, whilst 500 kg CO_2e has probably not (2). The 3,000€ income has the same common answer for every question even.

The answers are not as significantly different from each other as in the tax scheme. The 2,500 kg CO_2e is found to be significantly easier to implement within the *EU* and fairer to *individuals* than the 100 kg CO_2e, both for the 1,000€ budget. Additionally, for the *Enough* question the 2,500 kg CO_2e budget is significantly worse than the two other ones for both budgets. This therefore does not yield such a clear answer as before, it does however also not contradict the earlier findings.

When checking for differences between the incomes no answer significantly varies, indicating that the income does not play such an important role when it comes to trading. This does seem logical as there can be a redistribution from higher to lower incomes, reducing the importance of the initial income, as, other than the tax scenario, it is also possible to earn money instead of only spending it. However there is the risk of lower income households being forced to sell

their points to gain an additional income, and thus indirectly depriving them from the possibility of flying. Whilst this would be an explanation, it is questionable whether participants actually thought about these effects, given the short time span of the survey.
The interesting last question, which budget is the most fair and effective at the same time, was again answered with 500 for both budgets, both when looking at the averages (2.3 and 2.0) as well as the most common answer (2 for both).
None of these results change for the subset.
So again the same result as for the tax scenario can be drawn, with the 100 kg CO_2e getting outperformed and not having a clear distinction between the 500 and 2,500 kg CO_2e budget. Whilst 2,500 kg CO_2e is the preferred choice for four out of the five questions, 500 kg CO_2e is not significantly less preferred than 2,500 kg CO_2e and even thought to be significantly better to reach the 2030 emission reduction target (*Enough*). Additionally, 500 kg CO_2e is again thought to be the most fair and effective at the same time.

The predefined hypothesis for both the tax and the trading scenario, of 2,500 kg CO_2e being the most likely to be *accepted* and found the best to be implemented (*EU* & *Worldwide*), does hold. Especially in the tax scenario this difference is even significant. The second hypothesis of having a lower budget outperform 2,500 kg CO_2e for the *Enough* question also holds (significant difference for both scenarios under both budgets), as well as the last one of 500 kg CO_2e being chosen to be the most fair and effective at the same time.

Trading vs. tax
There are more significant differences within the tax scenario, with the 100 kg CO_2e always generating significantly less (more for the *Enough* question) points than the 2,500 kg CO_2e (exception: 1,000€, *EU* → only at the 10% level).
An important similarity for the two scenarios is that the 2,500 kg CO_2e budget is considered significantly worse than the other two to reach the 2030 goal for both scenarios and both incomes. Another interesting similarity is that there is never a significant difference between the 100 and 500 kg CO_2e budget (exception: Tax, 1,000€, *Enough*).
For both scenarios when asked which budget is the most fair and effective at the same time, the 500 kg CO_2e budget is favored. Income levels do not seem to be too important, as they do not change any of the answers significantly.
The subset also did not change any of the answer averages more than 0.1 (exception: Trading, 3,000€, 100 kg CO_2e, *Worldwide*) or the differences within the answers (exception: one more

significant difference for Tax, 3,000€, *EU*, 500 less than 2,500). The same holds for the most common answer.

When explicitly comparing the answers between tax and trading for the same question, same budget, and same income (e.g. *Enough*, 100 kg CO_2e, 1,000€) to explicitly test for differences between the scenarios, a slight tendency towards the tax scenario can also be seen. It almost always generates higher or the same average answers, as well as most common answers (exception: 1,000€, 100 kg CO_2e, *Individuals*). Only for the 2,500 kg CO_2e budget these differences are also significant (*EU* and *Worldwide* for both incomes & *Acceptance* for 3,000€). Here the tax scenario is considered to rather be implemented and accepted. Additionally, there are four cases where the difference is significant at the 10% level. So the tax scenario does seem to be more effective according to these differences. As always, there is a difference for the *Enough* question. Interestingly, here the trading scenario is the one to generate either more or the same average answer.

This is a very interesting outcome, as there does seem to be quite a tendency towards the tax scheme, with the *Enough* question being the exception. See Appendix B for the detailed results.

The hypothesis was that there would not be a significant difference between the schemes, which cannot be confirmed by the results. A further investigation of this difference will be done when in *comparison* part of this chapter.

Real scenario

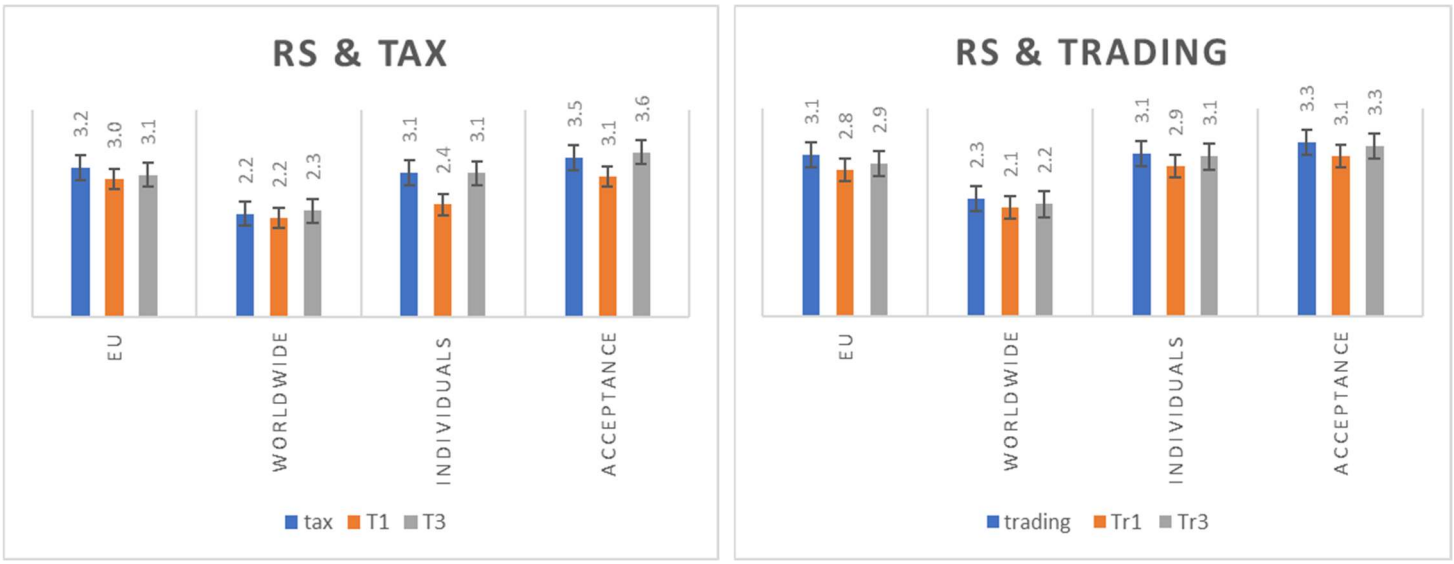


Figure 5: Outcome "Real Scenario", respectively for Real Scenario Tax (Trading) answers compared to Tax (Trading) 1,000€ (T1) (Tr1) and 3,000€ (T3) (Tr3) for the 100 kg CO_2e budget, including average answers and standard error bars. Full sample size (n=139)

The journey of comparing the two scenarios is continuing here. This third part reveals which of the three budgets would be needed to still be able to reach the 80% aviation emission reduction required to align with the Paris Agreement (100 kg CO_2e). As mentioned, this part should analyze whether giving additional information leads to differences in the answering behavior, a so-called "information nudge" effect. To test for this, the same four questions as before were asked (*Enough* question becomes redundant). This time no income was given.

As there are no significant differences between the tax and trading scenario could be found, the answers were also compared to the answers in the first part (Resource account – tax & trading) for the 100 kg CO_2e budgets there for both incomes, this can be seen in Figure 5. When examining the results, only two significant differences can be found. For the *EU* question the average answer rises significantly in both scenarios (for tax only significant at the 10% level). The second significant increase is for *Acceptance* where it rises for the tax scenario. This is all for the 1,000€ budget, there are no significant differences for the 3,000€ budget. For the subset there are slightly more differences, with there being a significant increase for the *EU* and *Individuals* in the tax scenario with a 1,000€ income. Both differences have only been significant at the 10% level before.

All in all it can be said that the additional information did not have a significant effect, therefore also not in line with the hypothesis. This is an important finding for policy makers as it indicates that people might be indifferent to knowing the exact amounts needed to reach the desired emission reduction. An information nudge therefore does not influence the outcome.

Comparison

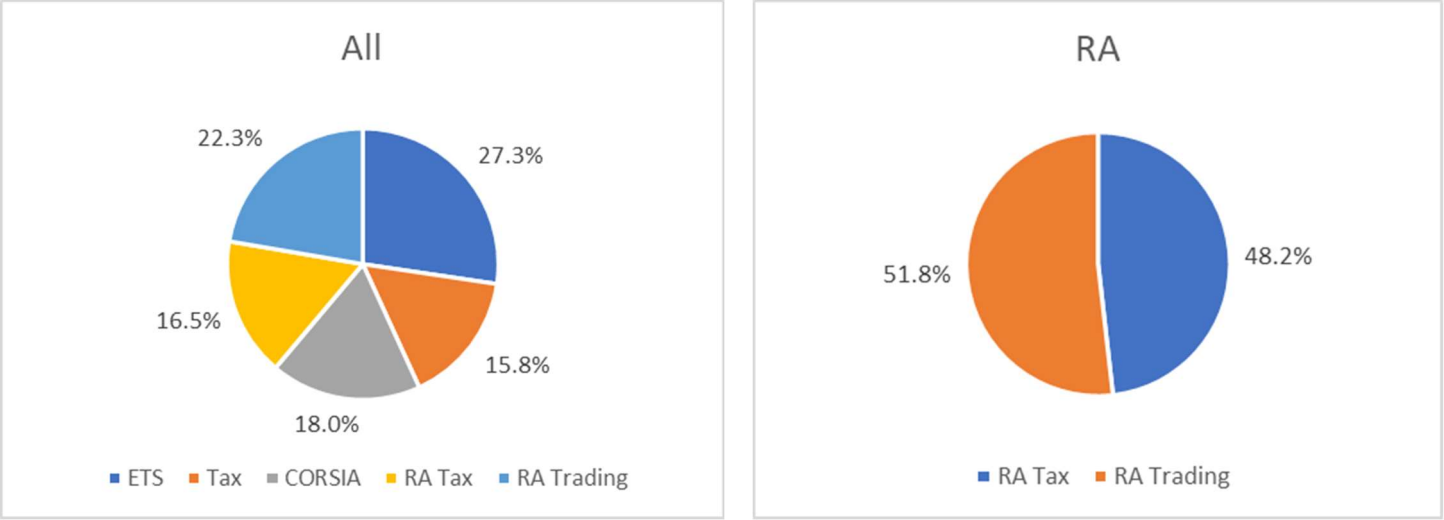


Figure 6: Outcome "Comparison", respectively for all five scenarios and only the RA tax and RA trading, including answer distribution in percent. Full sample size (n=139)

This is also a crucial part of the questionnaire. People were asked which scenario they find to be the most fair and effective at the same time, firstly giving the five options from part one (Status Quo), then again with only the two resource account scenarios.
As can be seen, ETS is the preferred option, followed by RA Trading and CORSIA. The RA Tax and a fixed tax take the last place. This follows the same explanation as in the first block of questions (Status Quo), where ETS and CORSIA were expected to be wanted a lot as there the airlines bear the costs instead of individuals, which is also in line with the hypothesis put forward. Surprisingly the RA trading which came out at the second "place". In general the two RA ideas are quite popular, indicating a high level of acceptance with 28.8% of surveyed people finding it the best solution of the five. When looking at the subsample the sequence of the answers does not change, with the RAs accounting for even more, 41.6% of the answers (RA trading 23.3% and RA tax 18.3%).

When only comparing the two RAs, the trading scenario is slightly ahead with 51.8% of people finding it fairer and more effective at the same time compared to the tax scenario (5 votes difference). This difference becomes even smaller for the subset, where RA trading gets 50.8% of the votes (2 votes difference). With such a minor difference, the hypothesis of no scenario being preferred, as also indicated by the literature on the subject, can be considered fulfilled (see chapter *literature*).

All things considered, this is a satisfying result, indicating that the two RA solutions would be an acceptable solution compared to the other ones presented.
The RA trading does seem to be preferred, however only by 1,8% (even only 0,8% in the sub-sample), therefore this statement should be handled with care.

Optimal outcome

To summarize, the main outcomes are stated as bullet points per scenario, to have a better overview.

Tax scenario

- **All differences**:
    - 2,500 kg CO_2e is valued higher than 500 & 100 kg CO_2e, and 500 higher than 100 kg CO_2e
    - It is exactly the opposite for *Enough*
- **Significant Differences**:
    - 2,500 kg CO_2e always significantly different to 100 kg CO_2e
    - 2,500 kg CO_2e six out of 10 times significantly different to 500 kg CO_2e (additionally 3x at 10% significance level)
    - 500 never significantly different to 100 kg CO_2e (exception: 1,000€, *Enough,* 100 significantly better than 500)

The significant differences here underline the general differences quite well, of 2,500 kg CO_2e often being significantly better (worse for *Enough*) than the other two, whilst the differences between 500 and 100 kg CO_2e are only insignificant.

Trading scenario

- **All differences**:
    - 2,500 kg CO_2e is valued higher than 500 & 100 kg CO_2e, and 500 higher than 100 kg CO_2e
    - It is exactly the opposite for *Enough*
- **Significant Differences**:
    - 2,500 kg CO_2e four out of 10 times significantly different to 100 kg CO_2e (additionally 2x at 10% level)
    - 2,500 kg CO_2e twice significantly different to 500 kg CO_2e (for *Enough*)
    - 500 never significantly different to 100 kg CO_2e (exception: 1,000€, *Individuals*, at 10%)

The pattern that can be seen here is that 2,500 kg CO_2e is always significantly worse than 500 & 100 kg CO_2e for *Enough.* Other than that almost all differences are insignificant, however they still move in the same direction as in the tax scenario and do therefore not interfere with the earlier findings.

Both scenarios

- **All differences**:
  - 2,500 kg CO_2e is valued higher than 500 & 100 kg CO_2e, and 500 higher than 100 kg CO_2e
  - It is exactly the opposite for *Enough*
- **Significant Differences**:
  - *Enough*: 2,500 kg CO_2e significantly worse than 500 & 100 kg CO_2e, but 500 only for Tax 1,000€ significantly worse than 100 kg CO_2e
  - 500 kg CO_2e never significantly better than 100 kg CO_2e
- **General findings**
  - Income, Mode and Subset do not significantly change any findings
  - Comparison question (most fair and effective at the same time): 500 kg CO_2e chosen in every scenario and income

Clearly 2,500 kg CO_2e "wins" the most questions when including insignificant differences, even though it always performs the worst for the *Enough* question. Interestingly, 500 does never perform significantly better than 100 kg CO_2e, and also always wins the question of which budget is the most fair and effective at the same time.
Also, for none of the scenarios and budgets the income played a role. Examining the Mode instead of the Mean and taking a subset as a sample also did not significantly change the outcome.

Tax vs. trading

When explicitly examining the differences between the two, the following conclusions can be drawn:

- **Enough**: Trading gets higher average answers
- **All other questions**: Tax gets higher or equal average answers
- **Explicit comparison**: Trading is the preferred option when comparing all 5 scenarios, and when only comparing the two RAs

As can be seen, it is quite difficult to see which scenario would be preferred. Whilst the tax scenario is thought to be the easiest to implement within the *EU* and *worldwide*, fairer to *individuals* and most likely to be *accepted*, the trading scenario is rather considered to be *enough* to reach the emission reduction goal. Additionally, when solely comparing the scenarios (either all 5 or only the two RAs), the trading scenario is preferred and even gets "second place"

amongst the five options. This makes it quite difficult to reach a conclusion as to which scenario should rather be implemented. As this is also in line with the literature, it is an acceptable, even if not quite satisfying, conclusion.

Whilst it is not possible to distinguish between the scenarios, there can be some assumptions made about the budget. Unsurprisingly, 2,500 kg CO_2e and therefore the highest budget would be the preferred amount. However, when examining the *Enough* as well as the comparison (fair and effective at the same time) question, this becomes less clear and 500 kg CO_2e seems to be the preferred amount. This indicates that whilst people do want a high amount, they do also realize that this is not sufficient *enough* to reduce our emission output accordingly. Even though it does not seem as important at first glance, 500 kg CO_2e is only four out of 16 possible times significantly worse than 2,500 kg CO_2e (excluding *Enough*), indicating that it is actually acceptable.
Interestingly, 500 is never significantly better than 100 kg CO_2e, indicating that it could be possible to reduce the budget even further. In a further survey, this should be tested for.

So, all in all, 500 kg CO_2e seems to be the most appropriate solution as it is considered the most fair and effective at the same time and does not perform too badly in the other questions in comparison to the two other budgets. Most importantly, it is also way closer to the environmentally desired budget of 100 kg CO_2e to achieve a reduction in aviation emissions of 80% by 2030. No decision can be made about the best scenario however, as both tax and trading seem to be equally accepted.

Demographics

This part analyzes whether demographics and the individual flight behavior influences the outcome. A summary of the demographics can be seen in Table 1.

	Category	N	%		Category	N	%
Gender	Female	50	36	**Highest degree**	Mandatory School	4	3
	Male	89	64		High School	69	50
	Other	0	0		Bachelor	39	28
					Master	25	18
					PhD	2	1
Age	< 20	1	1	**Employment**	Student	90	65
	20-25	79	57		Part-Time	11	8
	26-30	29	21		Full-Time	29	21
	31-40	15	11		Unemployed	1	1
	41-50	2	1		Retired	6	4
	51-60	4	3		Other	2	1
	> 60	9	7				
Monthly net income	< 1.000	59	42				
	1.000-2.000	52	37				
	2.000-3.000	14	10				
	3.000-4.000	8	6				
	4.000-5.000	1	1				
	> 5.000	5	4				

Table 1: Demographic characteristics of the full sample (n=139), including the amount of answers per category (N) and percentage (%).

The questions on the flight behavior can be divided into three subgroups (the exact questions asked can be found in Appendix C):

Behavior			
Category	Av.	St.Er.	Scale
Domestic	2.7	0.20	1-10
International	1.5	0.19	1-10
Leisure	67.5	2.87	%
Family	27.9	2.70	%
Work	13.7	2.20	%
Compensation	19.9	2.62	%

Willingness		
Category	Av.	St.Er.
Fly less	3.5	0.11
Mandatory Compensation	3.7	0.10
Restriction	2.9	0.12
RA	3.6	0.11

Thoughts		
Category	Av.	St.Er.
Problem	4.8	0.05
Concerned	4.5	0.07
Below 2°	2.3	0.08
Net zero	2.4	0.10

Table 2: Outcome "Flight Behavior", categorized into three groups (Behavior, Willingness, Thoughts), including average answers and standard errors.
For Behavior the scale was also included for better interpretation of the results. Scale for Willingness and Thoughts: 1 to 5.
Full sample size (n=139)

Quite some thought went into choosing the dependent variable for the regression analyses, as there were quite a few to choose from. The decision came down to the comparison question (Which budget do you think would be the most fair and effective at the same time?) at the end of each section (Tax 1,000€, Tax 3,000€, Trading 1,000€ and Trading 3,0000€), as this question looks at both aspects (fairness and effectiveness), making it a suitable choice. The real scenario was not used, as it did not lead to a significantly different outcome than before, therefore it is also not expected to lead to a different outcome in the regression analysis. Lastly the comparison question between the two RA scenarios was used.

To identify the independent variables that best explain the dependent ones, a stepwise backward regression was used. The ideal model should have a high adjusted R^2, whilst still having a sufficient p-value of the F-statistic. Additionally to this manual approach, a stepwise regression using the Akaike Information Criterion (AIC) and Bayesian information criterion (BIC) respectively, was performed. Out of these three models, the one that with the most significant variables, highest adjusted R^2 and lowest p-value was chosen as "best fit" and depicted in Table 3. Interestingly, this turned out to always be the outcome of the stepwise regression using AIC.
Regression analyses always bear the challenge of possible correlation, as some questions will probably be correlated by nature. More so for the willingness and thoughts group, maybe less for the behavior. To tackle this, the variance inflation factor (VIF) was used to test for multicollinearity. The VIF never exceeded five in any scenario, indicating that multicollinearity was not a problem.

	Tax 1,000€	Tax 3,000€	Trading 1,000€	Trading 3,000€	RA comparison
Constant	2.56291 (0.262)***	3.17958 (0.298)***	2.54442 (0.254)***	3.42562 (0.330)***	2.14685 (0.162)***
Domestic					-0.03503 (0.018)*
International					
Leisure					
Family	0.00405 (0.002)*		0.00475 (0.002)**		0.00221 (0.001).
Work	0.00563 (0.002)*	0.00469 (0.002)*	0.00447 (0.002)*	0.00517 (0.002)*	
Compensation	-0.00629 (0.002)***	-0.00563 (0.002)**	-0.00551 (0.002)**	-0.00293 (0.002)	
Fly less		-0.12733 (0.043)**		-0.09706 (0.046)*	
Mandatory Compensation				-0.12308 (0.057)*	-0.09572 (0.034)**
Restriction	-0.11008 (0.047)*		-0.06448 (0.046)		
RA	-0.09194 (0.052).	-0.22742 (0.045)***	-0.14477 (0.050)**	-0.15618 (0.054)**	
Problem Concerned					
Below 2°					
Net zero					
Gender		-0.17300 (0.111)		-0.21065 (0.119).	
Age		0.09488 (0.037)*		0.09031 (0.040)*	-0.08264 (0.028)**
Education	0.13069 (0.069).		0.18383 (0.067)**		
Employment					
Income	-0.09083 (0.052).		-0.07764 (0.050)		
adj. R-squared	0.2557	0.3609	0.272	0.287	0.1329
F-statistic	7.773	13.99	8.366	8.936	6.288

*Table 3: Regression output for the full sample size (n=139); Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

All p-values of the F-statistic are close to zero, indicating that these models fit the data better than a model with no independent variables at all. An adjusted R^2 between 0.26 and 0.36 as well as 0.13 for the last regression is a quite satisfying result, indicating the amount of the variance of the dependent variable explained by the corresponding independent variables, even though not too much weight should be put on R^2 as selection criterion, as it in general is not an indicator for a "good" or "bad" model.

Some interesting conclusions can be drawn from the independent variables. When comparing the first four regressions, *Compensation, RA* and *Work* are significant for all.
This indicates that an increase of *Compensation* (*RA*) of one, leads to a reduction of the average answer for the dependent variable by 0.3 to 0.62% (9.2 to 22.74%). If one is to believe the assumption that people who are compensating their flight emissions are aware of the negative environmental externalities of their flight behavior, and therefore do care more about containing global warming, it seems appropriate to conclude that these people would rather choose a lower budget. The *RA* variable (representing the support of an introduction of an individual emission account for flights) is even more influential and suggests an awareness and willingness to reduce emissions, resulting in the support of a lower budget. This can also be seen in the subset, with the two variables still being significant for three out of the four regressions[5].
The same conclusion can be drawn from the two other variables of the *Willingness* block that can be deemed significant, the willingness to *fly less* (Tax and Trading 3,000€) as well as the support of a *restriction* on the number of flights per person (Tax and Trading 1,000€).

For *Work* the opposite holds, it leads to an increase of the average answer of 0.45 to 0.56%. The same holds for *Family* (Tax and Trading 1,000€) and *Work* (Tax 1,000€, Tax 3,000€ and Trading 3,000€). An explanation could be that whilst flying for leisure is voluntary, flying to visit family or to work might be less so and can also not be substituted as easily. Perhaps those participants find a lower budget less fair, as they feel they cannot influence their flight behavior as easily and must then bear higher ticket costs. Additionally, *Family* is significant for Tax 3,000€ within the subset.
It should be mentioned that these last four variables from the *Behavior* block have a rather high standard error (Table 2). As the scale here is not 1-5 but 0-100%, the resulting standard errors are accordingly higher. All other standard errors are within an acceptable range.

[5] Subset: *Compensation* not significant anymore for Trading 3,000€ and *RA* for Tax 1,000€.

Rather unexpectedly, no variable from the *Thoughts* block is included in any of the models. An explanation could be that these questions were asked in a too "obvious"[6] way and therefore let to a quite homogenous answering pattern, not generating meaningful results. This does also only change once for the subset, with *Concerned* now being significant for Tax 1,000€.
The same holds for the number of *Domestic* and *International* flights per year, *Leisure* as primary reason to take flights as well as the current *Employment* status. Also, *Mandatory Compensation* is only included once (Trading 3,000€). Interestingly, *Domestic* does become significant within the subset for Tax and Trading 3,000€, however with a significance level >10%. This indicates that, at least for the subset, the more flights participants took (domestically) within one year, the more likely they were to decide on a higher emission budget. Whilst this does seem intuitive and is also in line with one of the hypotheses put forward, it is interesting that this is only the case for the subset. No explanation could be found on why this is the case. See Appendix D for a regression output of the subset.

The outcome of the demographics block is quite interesting. Before going into the details it should be mentioned and kept in mind that five out of the eight significant variables are only significant at the 10% level at most. In sum, this is significantly less than for the other two blocks (9/10 for *Behavior* and 7/9 for *Willingness*).
Gender and *Age* are significant for Tax and Trading with an income of 3,000€, however not for 1,000€. So whilst females rather chose a lower budget, older people were more likely to select a higher one. When examining the other demographic indicators it can be seen that *Education* increases the likelihood to choose a higher budget, whilst *Income* decreases it. This is quite interesting, as Education and Income are often correlated and would therefore suggest the same direction of movement of the outcome, which is not the case here. Other than for the first two variables, this now only holds for Tax and Trading with an income of 1,000€, however not for 3,000€.
In contrast to the other blocks, no explanation could be found to why the demographic variables influence the outcome in this way. It seems to be a coincidence that for each income (1,000€ or 3,000€) a different pair of variables turns out to be significant (Gender & Age or Education & Income). Again, a considerable amount of these variables has a rather low significance level (≥ 10%).

[6] Example *Problem*: *Do you think global warming creates environmental problems?* – With an average answer of 4.8 it can be concluded that many participants recognize the problem and answer in a similar way. This leads to the variable not providing significant indications in the regression analysis.

For the subset, *Gender* becomes insignificant for Tax 3,000€ and *Education* for Trading 3,000€, versus *Employment* now being significant for Trading 3,000€.

In the last regression, it was tested which variables influence the outcome to the RA comparison question, so which RA (tax or trading) participants find to be the most fair and effective at the same time. The results show the amount of *Domestic* flights per year, the willingness to support *Mandatory Compensation* and *Age* decreasing the dependent variable, suggesting a tendency towards the tax scheme. In contrast, *Family* as primary reason for air travel indicates a preference towards the trading scheme. No explanation could be found on why these variables are significant, therefore this outcome is considered rather random and no further conclusion can be drawn from the available data This might also be endorsed by the question being binary (tax or trading).
Interestingly, the subset shows three additional variables as significant (*Leisure*, *Concerned* and *Education*). Family, being significant only at the 10% level prior, is now not significant anymore. Again, no further conclusion could be drawn from this outcome.

The overall conclusion from this regression analysis is that there indeed are variables that indicate a tendency towards a lower budget, namely *Compensation* as well as all variables of the *Willingness* block. The opposite holds for *family* and *work* as primary reasons for flying. Compared to flying for leisure, they cannot be substituted for as easily, which might be the explanation for this outcome. What is less intuitive is the influence of personal demographics. Whilst being female and having a lower income indicates a preference towards a lower budget, the opposite holds for an older age and having a higher educational background. No explanation could be found for this outcome.
The same holds for the regression output on the RA comparison question, for which no explanation could be found on why certain variables turned out significant.

This is somewhat in line with the hypothesis put forward, of all three blocks of variables significantly reducing the budget chosen, however the *Thoughts* block does not play a significant role. The number of domestic and international flights does not influence the outcome significantly, which is not in line with the proposed hypothesis. What is in line, is demographics not playing a crucial role, which might be due to the sample population not being representative enough of the different characteristics. Also in line is work as primary reason for flying, leading to a preference of a higher budget.

Conclusion

How can we make environmentally harmful actions “costly” without generating social inequality? – The leading question of this thesis. So, what is the answer? As so often in research, it depends.

The resource account can keep up with the already existing aviation emission schemes and even a statement about the optimal budget can be made, with 500 kg Co_2e being, considering all aspects, the most suitable. However, it is important to keep in mind that this budget will not be sufficient to achieve the Paris Agreement's target of an 80% reduction in aviation emissions by 2030.

What would be needed is a budget of 100 kg Co_2e at most, which was the least popular in this survey, even after revealing that this would be needed to stay in line with the defined target. The 100 kg Co_2e budget was however not significantly less accepted than 500 kg Co_2e, so when only providing these two or even lower budgets, there might be a different outcome. Further research must be conducted on the optimal emission budget. As 2,500 kg Co_2e is 25 times over the environmentally desired level, it was set too high and should not be included in further surveys.

The survey's most intriguing question was about fairness and effectiveness (Which budget do you think would be the most fair and effective at the same time?), as it captures both variables, whilst all other questions only targeted one aspect, making the outcome quite predicable.

No conclusive statement can be made about the scenarios, with both tax and trading being equally accepted. This aligns with current research, and further investigation is needed.

After examining various personal factors that could affect participants' responses, it seems that certain observations can be made in relation to their flight behavior. Generally, individuals who are already taking steps to offset their aviation emissions and are willing to modify their flying habits in order to reduce emissions are more willing to accept a lower emission budget for the resource account. What increases the likelihood of choosing a higher emission budget are family and work as primary reasons for flying. Compared to flying for leisure, they cannot be substituted for as easily, which might be the explanation for this outcome.

What is less intuitive is the influence of personal demographics. Whilst being female and having a lower income indicates a lower budget, the opposite holds for an older age and having a higher educational background. No explanation could be found for this outcome. This could however

be a drawback from the rather small and non-representative sample size and more research is needed to draw any definitive conclusions. Additionally, it would be beneficial to thoroughly examine the social effects of the trading scenario to determine whether it would ultimately improve or worsen conditions for private households.
During the survey, two different income variables were investigated, but no significant difference was identified, suggesting that the testing may not have been comprehensive enough as income is considered to play a crucial role.

Aspects that were not captured in this survey were substitution effects to others forms of transport as well as elasticity effects on the pricing. What has to be considered as well is that the survey did not capture non-commercial flights (e.g. cargo flights, private jets, helicopters), despite producing a substantial amount of emissions. However, regulating essential activities such as rescue or cargo flights is not feasible as they are unavoidable. It is also questionable whether such a scheme would influence flights with private aircrafts, as even a price increase of a few hundred euros is neglectable in these cases.

The general idea behind the resource account is of course not limited to aviation emissions and it would be interesting to analyze it for other sectors as well. Especially the social consequences of the trading scheme and the potential amount of emission reduction could not be examined in detail and need more research.

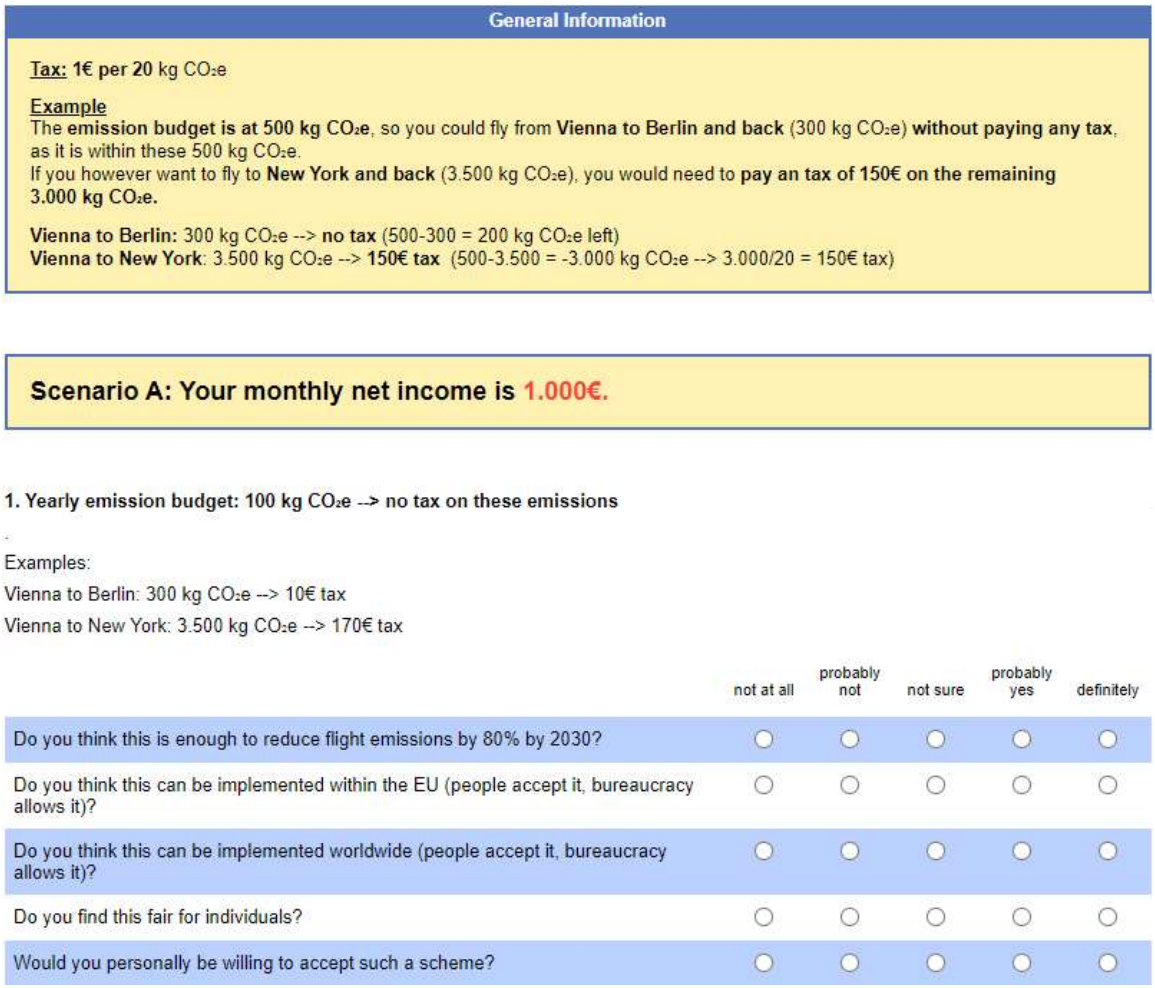
All in all, the resource account does seem to be an option to reduce (aviation) emissions by targeting private individuals who have not yet been covered by any kind of scheme. The answer to why is probably a political one. With fringe parties gaining influence in almost all European countries, political as well as societal tensions increased significantly over the last years, having environmental protection as one of the most discussed topics. Besides the logistical, technical, and economic challenges of implementing such a scheme, the risk of public discontent and political instability seems to be the main implementation obstacle.

Nevertheless, if countries are truly committed to achieving the Paris Agreement targets, they must consider private emission production as well, it will not be sufficient to only target companies. We can already see and feel the disastrous consequences of this climate crisis, and drastic times require drastic measures, as the saying goes.

Appendix

Appendix A: Illustration of the online survey.

Example question: Tax scenario; 1,000€ Income; 100 kg CO_2e budget



General Information

Tax: **1€ per 20** kg CO_2e

Example
The **emission budget is at 500 kg CO_2e**, so you could fly from **Vienna to Berlin and back** (300 kg CO_2e) **without paying any tax**, as it is within these 500 kg CO_2e.
If you however want to fly to **New York and back** (3.500 kg CO_2e), you would need to **pay an tax of 150€ on the remaining 3.000 kg CO_2e.**

Vienna to Berlin: 300 kg CO_2e --> **no tax** (500-300 = 200 kg CO_2e left)
Vienna to New York: 3.500 kg CO_2e --> **150€ tax** (500-3.500 = -3.000 kg CO_2e --> 3.000/20 = 150€ tax)

Scenario A: Your monthly net income is 1.000€.

1. Yearly emission budget: 100 kg CO_2e --> no tax on these emissions

Examples:
Vienna to Berlin: 300 kg CO_2e --> 10€ tax
Vienna to New York: 3.500 kg CO_2e --> 170€ tax

	not at all	probably not	not sure	probably yes	definitely
Do you think this is enough to reduce flight emissions by 80% by 2030?	○	○	○	○	○
Do you think this can be implemented within the EU (people accept it, bureaucracy allows it)?	○	○	○	○	○
Do you think this can be implemented worldwide (people accept it, bureaucracy allows it)?	○	○	○	○	○
Do you find this fair for individuals?	○	○	○	○	○
Would you personally be willing to accept such a scheme?	○	○	○	○	○

Appendix B: Detailed comparison of Tax and Trading answers, respectively with the mean and malus.
The cells highlighted in green indicate the higher average or most common answer between the tax and trading scenario.

	Tax vs. Trading 1.000€					
	100		500		2500	
	Tax	Trading	Tax	Trading	Tax	Trading
Enough	2.8	2.8	2.4	2.6	2.0	2.3
EU	3.0	2.8	3.2	3.0	3.5	3.1
Worldwide	2.2	2.1	2.3	2.2	2.6	2.3
Individuals	2.4	2.9	3.1	3.1	3.4	3.2
Acceptance	3.1	3.1	3.2	3.2	3.5	3.3

	Tax vs. Trading 3.000€					
	100		500		2500	
	Tax	Trading	Tax	Trading	Tax	Trading
Enough	2.5	2.6	2.3	2.4	2.0	2.1
EU	3.1	2.9	3.3	3.0	3.5	3.1
Worldwide	2.3	2.2	2.4	2.3	2.7	2.4
Individuals	3.1	3.1	3.3	3.3	3.6	3.3
Acceptance	3.6	3.3	3.7	3.4	3.9	3.4

	Tax vs. Trading 1.000€					
	100		500		2500	
	Tax	Trading	Tax	Trading	Tax	Trading
Enough	2.0	2.0	2.0	2.0	1.0	2.0
EU	4.0	3.0	4.0	4.0	4.0	4.0
Worldwide	2.0	1.0	2.0	2.0	2.0	1.0
Individuals	2.0	3.0	4.0	4.0	4.0	4.0
Acceptance	4.0	4.0	4.0	4.0	4.0	4.0

	Tax vs. Trading 3.000€					
	100		500		2500	
	Tax	Trading	Tax	Trading	Tax	Trading
Enough	2.0	2.0	2.0	2.0	1.0	2.0
EU	4.0	4.0	4.0	4.0	4.0	4.0
Worldwide	2.0	2.0	2.0	2.0	2.0	2.0
Individuals	4.0	4.0	4.0	4.0	4.0	4.0
Acceptance	4.0	4.0	4.0	4.0	5.0	4.0

Appendix C: Questions asked in the flight behavior part of the survey. The italics words at the beginning indicate the abbreviation used in Table 1.

Behavior

- *Domestic/International*: How many round trips (flying back and forth) do you on average take per year (excluding Covid years)?
    - This was asked for both domestic and international.
    - Answer possibilities: 0 to 10 for both questions
- *Leisure/Family/Work*: Your main purpose to fly is leisure, family, work
    - Answer possibilities: 0 to 100% for all three questions
- *Compensation*: For how many flights, if any, do you compensate the emissions?
    - Answer possibilities: 0 to 100%

Willingness

To decrease global warming I am/would be willing to:

- *Fly less*
- *Compensation*: support mandatory compensation of flights
- *Restriction*: support a restriction on the number of flights per person
- *RA:* support an introduction of an individual emission account for flights

Answer possibilities for all questions: same 5 as for the previous parts (*not at all* to *definitely*)

Thoughts

- *Problem*: Do you think global warming creates environmental problems?
- *Concerned*: Are you personally concerned about global warming and climate change?
- *Below 2°*: Do you think we can keep global warming below 2° Celsius?
- *Net zero*: Do you think the EU can reach net zero (0 net emissions) by 2050?

Answer possibilities for four questions: same 5 as for the previous parts (*not at all* to *definitely*)

Appendix D: Regression output for the subset (n=120).

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

	Tax 1,000€	Tax 3,000€	Trading 1,000€	Trading 3,000€	RA comparison
Constant	2.83664 (0.384)***	2.82046 (0.264)***	2.49050 (0.268)***	3.71638 (0.359)***	2.70583 (0.308)***
Domestic	0.04890 (0.031)		0.04581 (0.032)		-0.06664 (0.023)**
International					
Leisure					-0.00310 (0.001)*
Family	0.00356 (0.002).	0.00326 (0.002).	0.00630 (0.002)***		
Work	0.00803 (0.003)**	0.00592 (0.003)*	0.00650 (0.003)*	0.00780 (0.003)**	
Compensation	-0.00570 (0.002)**	-0.00561 (0.002)**	-0.00467 (0.002)*		
Fly less		-0.13950 (0.047)**		-0.11481 (0.049)*	
Mandatory Compensation				-0.15814 (0.060)**	-0.08056 (0.039)*
Restriction	-0.11141 (0.045)*		-0.06653 (0.047)		
RA		-0.21737 (0.051)***	-0.12889 (0.054)*	-0.16372 (0.060)**	
Problem Concerned	-0.16227 (0.082)*				-0.09712 (0.061)
Below 2° Net zero					
Gender				-0.25857 (0.129)*	
Age		0.08133 (0.040)*			-0.09236 (0.031)**
Education	0.17557 (0.075)*		0.17958 (0.071)*		0.07644 (0.05)
Employment				0.10347 (0.053).	
Income	-0.14323 (0.056)*		-0.12240 (0.054)*		
adj. R-squared	0.3123	0.3552	0.3232	0.3114	0.1629
F-statistic	7.754	11.92	8.103	9.97	4.859

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