CHAPTER 4

The Development of the Questionnaire

This chapter[1] presents the development of our survey questionnaire and the results of the subsequent validation efforts. The questions address the areas of climate-relevant behaviors discussed in the previous chapter and are based on the various existing scales, lifestyle calculators, and surveys, such as the ECHOES project introduced in the previous two chapters. We, however, go beyond these existing questions and questionnaires as we also include various new items and analyze the validity of existing and new questions. For this purpose, we conducted a survey in two waves and also collected additional material from our respondents. The final data set is available at the Austrian Social Science Data Archive (Hadler et al., 2021).

4.1 Questions Included in Our Survey

As pointed out in the previous chapters, we also aim to explain emission-relevant behaviors and thus also include questions on environmental attitudes and personal PEB and various socio-demographic variables since previous research has highlighted their significance (Diekmann & Preisendörfer, 1992, 1998; Stern, 2000; Dunlap & Jones, 2002; Gatersleben et al., 2002; Marquart-Pyatt, 2008; Huddart Kennedy et al., 2015). The general environmental behavior and attitude questions are mostly equivalent to those of the International Social Survey Programme (ISSP, 2019; www.issp.org) and the emission-specific items to those used

[1] Lead authors: Markus Schweighart and Rebecca Wardana.

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Table 4.1 Overview of areas within the questionnaire (first wave)

Housing	Building information	Direct energy
	Heating and heating behavior	
	Power consumption	
	Water treatment and water consumption	
Mobility	Individual motorized means of transport (car, motorcycle, and public transport)	Direct energy
	Flight behavior	
Diet	Consumption of animal products	Indirect energy
	Waste	
Consumption	Consumption of goods (e.g., purchasing of clothing and other goods)	Indirect energy
	Consumption of information (e.g., purchasing of electronic devices)	
	Leisure activities	
Not emission-related items	General environmental attitude	
	PEBs	
	Socio-demographic as important influencing variables	

in the ECHOES project (Reichl et al., 2019). Table 4.1 provides an overview of the areas for the measurement of individual emission-relevant behavior and other areas that are included in our initial survey. The six areas—housing, mobility, diet, consumption of goods, consumption of information, and leisure activities—are based on the considerations presented in Chap. 3. The detailed list of questions can be found in the Appendix of this book.

The follow-up survey focused mainly on the car use of the respondents since the time of the first survey. In the first survey, respondents were asked to indicate the mileage of their most frequently used car and for an estimate of how often they used it (both in kilometers and in hours). In the second wave of the survey, they were asked to estimate their mileage since the last survey and to provide their current mileage of the same car. This enabled an approximate projection of car use over the entire year, and these mileage figures could also be used to validate the respondent's own assessment. The following questions were included in the second wave.

- Do you live in ownership or rent? (refers to residential property at the first survey date)
- How many kilometers have you traveled since the last survey at the end of February/beginning of March? (estimate)

- What is the current mileage of your most used car? If this is no longer the car we asked you about last time, we do not need the mileage. (mileage at second time)
- How many times has this car been used by others since February/March without you in it? (never, almost never [about 10% of the km], rarely [about 25% of the km], about half of the time [about 50% of the km], and often [75% of the km or more])

4.2 Samples

The survey was conducted in two waves and focused on urban, suburban, and peripheral regions. Our sample (Hadler et al., 2021) includes the Austrian capital, Vienna, and the capital of the province of Styria, Graz, which is the second largest city of Austria, with about 300,000 inhabitants. Within these two cities, a new subdivision into "bourgeois districts" and "workers' districts" was made. One "bourgeois district" and two "workers' districts" were selected for the survey since it was assumed that the bourgeois districts would be more willing to participate. The areas around Vienna and Graz were selected for the suburban area. These regions were again subdivided according to size and accessibility in order to achieve a higher comparability, on the one hand, and, on the other hand, to provide good public transport connections for the interviewers. In order to also cover rural areas within the sample, more remote areas were sought. The two municipalities of Murau in Styria and Waidhofen an der Thaya in Lower Austria as well neighboring villages were chosen. Once the locations for the sampling had been determined, the respondents were chosen randomly from the online telephone book "Herold."

In the first survey wave, a total of 209 persons were interviewed in February and March 2019. Due to the complexity of the questions and the additional validation questions, the questionnaire in the first survey was filled out in face-to-face interviews. In total, there were 12 interviewers who were trained to administer the survey. The questionnaire was presented to the respondents by the interviewers, who had an extended version of the questionnaire that included the validation questions. The final answers were completed by the interviewers themselves. In addition, some of the respondents were asked how confident they were in answering the questions.

It was also specified that the first survey should be conducted in the respondents' private households as some questions required proof of

certain receipts (e.g., heating and electricity bills) and included questions about the household's equipment (e.g., electrical appliances or insulation measures). If the respondents did not agree with taking the survey in their own household, a neutral location was suggested to them. In the end, only those persons who indicated the mileage of their most frequently driven car were asked whether they would be willing to be available again for a follow-up survey. The main objective of this second survey wave was to determine the mileage of the respondents since the first survey date.

Our sample for the first wave consists of 52.2% male and 47.8% female respondents. Overall, 36% of the sample come from urban areas (13.2% from Graz and 22.8% from Vienna), 41.6% live in the suburbs around Vienna and Graz, and 22.4% live in the countryside. The respondents are between 20 and 94 years old, with the average age being 55 years. The majority of the sample consists of predominantly older respondents. The distribution of the educational qualifications shows that 38.5% have a university degree, 27.8% have a high school degree, and 17.3% an apprenticeship certificate. Regarding income, both the individual monthly net income and the total monthly net income of a household were asked. The average net income of a person within the sample lies between €1751 and 2000 per month. The average total net income of a household is between €2751 and 3000 per month. Looking at the composition of households, 78.5% of respondents live without children under 18 years of age. Of these, 23.4% are one-person households, and 62.7% live in a two-person household (two adults). Only around 10% live with one or two children under the age of 18 in a household.

Comparing these figures with the socio-demographic distributions of Austria, it becomes clear that the sample collected shows an above-average representation of the older generation and people with an academic degree as well as an under-representation of people with an apprenticeship certificate. By comparison, the average age in Austria is 42.9 years, and the proportion of persons over 60 years of age is 25.4% (Statistik Austria, 2020a). In comparison, the share of people aged over 60 in the present sample is over 40%. Moreover, the average individual monthly net income of the sample is below Austria's average net income (€2226 per month; Statistik Austria, 2020b). Another over- and under-representation is also evident in the distribution of educational attainment. Austria-wide data show that a total of 17.5% of the Austrian population has a university degree and that apprenticeship qualifications are the most common educational qualification in Austria, with 34.1% (Statistik Austria, 2020c).

A total of 141 persons were eligible for the second survey wave on the basis of the first survey wave as they indicated that they use a car, and the second survey focused on this. In the end, a total of 68 persons were willing to take part a second time. They were contacted by telephone in October and November 2019. They were given the opportunity to conduct the interview by phone or online via a link if they did not have time to answer at the time of the call. They were asked a total of five questions focusing on individual car use since the last survey. At the end of the survey phase, all respondents were sent an individual CO_2 profile, if desired.

A comparison between the socio-demographic distribution of the first and second survey waves shows that more men than women were reached in the second survey wave. In addition, significantly more older people were included in the second survey wave. Persons in suburban and rural areas were reached more often in the follow-up survey than persons in the city. The distribution of educational attainment is similar in both survey waves although it should be noted that in the second survey wave, significantly more persons with a vocational higher education degree (BHS) were reached compared to those with a general higher education degree (AHS).

4.3 Validation of Our Questions

A central issue of the project concerns the validation of questions regarding the suitability for the collection of GHG emissions. In the present case, a question is valid if it refers to behavior that is associated with GHG emissions and if it actually measures this behavior. The first point refers to the content relevance of the questions with regard to the GHG emissions caused by the respondent. Chapters 2 and 3 dealt with this *content validity* by reviewing the literature on the topic of GHG-relevant behavior and presenting the empirical findings to date as well as through calculations using the LCA approach. The areas that are most significant in terms of emissions have been identified, which are mobility, housing, diet, and consumption. It is only for these areas that it makes sense to formulate questions to ascertain emission-relevant behavior. In order to verify that the questions actually measure the named behavior, different question variants can be compared with each other and an external criterion. In this way, criterion validity is assessed. Additionally, participants can be asked directly whether or not they think that their responses are accurate to also cover the subjectively assessed validity.

The following sections now address these validity issues for the various relevant behavioral domains. The procedure thereby will always include the same points, as follows: (1) a comparison of various question variants regarding answer distributions, missing answers, and so on; (2) comparison with an external criterion; and (3) the results of the respondent's self-assessment of how confident they were with the answers they gave (where possible[2]). For this last aspect, respondents were asked after the regular survey how confident they were with their answers to certain questions on a 5-point response scale ranging from "very confident" to "very uncertain."

Housing

To determine the GHG emissions due to space heating, a number of variables were collected and used for the calculation, including the living space, the number of people living in the household, the type of dwelling (single-family house and similar), the age of the dwelling, the degree of insulation, the main energy source used, the type of heating system, and various behavioral variables, such as turning the heating down in different cases or the temperature at which the heating is applied. In addition, the heating costs per month and the heating energy consumption, which is listed in the heating bill, were also asked. In addition, the temperature in the living room was measured by thermometer during the survey.

The main influencing factors regarding heating emissions per capita are the floor space, the number of persons living in a household, and the type of main source of energy used (thus the kind of fuel) (Schweighart et al., 2020). If the type of dwelling and the thermal insulation are added, the explanatory power for heating emissions increases to approximately 70%. This value can only be increased insignificantly by adding behavioral variables, such as turning down the heating or temperature control. This does not mean, however, that the influence of the individual is not present in this area. Rather, the possibility of influencing their heating-related footprint can be found in the decision regarding their own living situation. Since a subsequent thermal refurbishment or a change of the main energy source is often not possible without high costs, the choice of apartment is of great importance. Since, however, ecological motives are unlikely to be the decisive factor in the decision for or against a particular form of

[2] Due to the already demanding survey format, we refrained from asking respondents for this self-assessment for each question.

housing, but rather financial, occupational, and lifestyle reasons, the effect of ecological attitudes on actual emissions can nevertheless be classified as comparatively low in this area.

Heating emissions were estimated based on these technical variables. To validate these numbers, we used the heating energy demand and heating costs found on energy bills. The results show strong correlations with the calculated magnitude of heating emissions even though the validation criteria do not include the main energy source as an essential factor. The correlation between heating costs and heating emissions is stronger ($r = 0.67$, $p < 0.01$) than the correlation between the energy demand according to the heating bill and the heating emissions ($r = 0.53$, $p < 0.01$). However, the number of those who could or wanted to present a heating bill was relatively small (29% or 14% of all respondents), which is why more detailed analyses were not carried out here. However, the strong correlation with the calculated quantity speaks for the validity of the calculated quantity and the central variables used. Regarding the monthly heating costs, more data are available as 83% of the respondents provided this information. Therefore, more detailed models could be calculated here. The floor space, the number of persons in the household, the thermal insulation, and the dwelling type turned out to be the strongest predictors of heating costs per capita. Respondents also expressed a high degree of confidence in the accuracy of their statements. For example, 82% are "very confident" about the accuracy of the living space they reported. In summary, the results are a clear empirical indication of the relevance and validity of those questions.

To cover not just technical features but also a behavioral aspect of housing, we will now deal with room temperature setting. This was included in the questionnaire in two different ways—by asking (1) what temperature the most frequently used room is heated to during the day and by asking (2) how the apartment temperature is assessed compared to other apartments (5-point scale from "considerably lower temperatures" to "considerably higher temperatures").

Additionally, the interviewers placed a thermometer in the living room during the interview.[3] The results show that the self-reported and the measured temperature are strongly related ($r = 0.58$, $p < 0.01$). For explaining heating costs, the thermometer measurement exhibits a clearly higher portion of explained variance than the self-reported temperature.

[3] The survey period in February and March 2019 falls within the heating period.

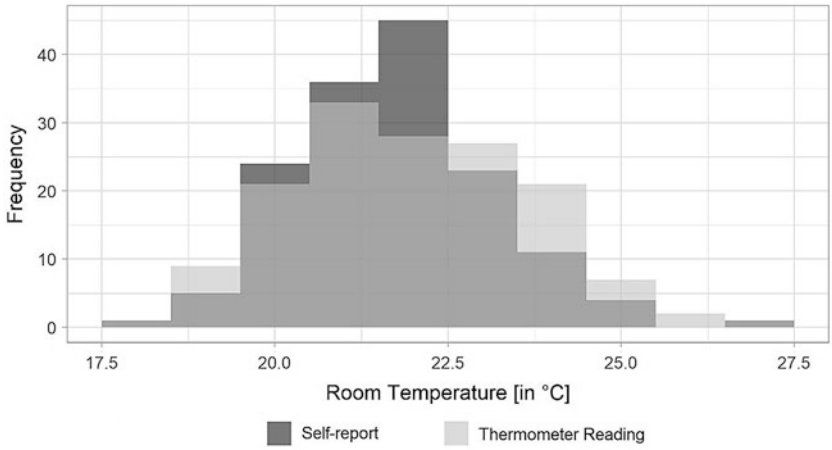

Fig. 4.1 Distribution of temperatures according to self-reported data and thermometer measurement. (Source: OeNB sample Hadler et al., 2021)

The punctual measurement by thermometer could therefore supply better results because here neither social desirability nor fuzziness in communication (e.g., in understanding the question) plays a role.

Comparing the distributions of the self-reported and measured temperatures (Fig. 4.1), it can be seen that more temperatures above 22.5 °C were recorded by thermometer and that the self-declarations are overrepresented in the range between 19.5 °C and 22 °C. In addition to a simple underestimation of the temperature, social desirability could also be an explanation in that one wants to appear to be energy-saving. Another explanation for this could be that the thermometer measurement was only taken at a certain point in time and that the presence of several people in the living room also leads to a slightly higher temperature.

Regarding the question about the temperature estimation compared to other apartments, we find that the answer category "considerably lower temperature" was not chosen by the respondents at all and that approximately 50% put themselves in the category "as average." If we compare the measured temperatures given for each category, we can see that people who state that they have warmer homes than others actually heat to higher average temperatures but that the difference between the categories "lower than average" and "average" is very small. This question therefore allows for fewer meaningful distinctions.

Interestingly, the argument that this question has fewer categories but is easier to answer does not apply as fewer respondents say they are "very confident" about the accuracy of the information they provide compared with the question on the exact temperature (43% vs. 58%). In short, the question on the assessment of the temperature compared to other homes allows fewer meaningful distinctions as it is less suitable from this point of view for depicting the interior temperature as an aspect relevant to heating energy.

On the basis of these findings, the questions about the living space, the main energy source, and the thermal insulation prove to be well suited to approximate heating emissions since they assert the largest influences. Regarding behavior, the temperature setting appears to have the largest effect and is best determined by asking directly about the temperature.

Mobility

The *intensity of car use* was surveyed with two variants—one question asked about the kilometers traveled in the previous year, and another asked about the average time spent in the car per week. The phrasing of the questions themselves shows that somewhat different things are addressed. The question about kilometers traveled clearly contains a time frame in the question, namely the previous year, and aims at an estimation of the total distance in kilometers. This means that non-routine journeys, such as those made during vacation periods, are also included. The question about the time per week in the car does not specify a clear time period, so that reference is more likely to be made to current usage. The addition of "on average" opens a certain space for interpretation—the person questioned is free to choose the period over which he or she calculates the average. Furthermore, "on average" can be interpreted as an indication to make a rough estimate. Also, the interpretation that the question refers to an average week is possible, whereby then again vacation trips would not be covered.

An indication that something different is being measured with the two questions can be found in different response patterns. To get an idea of this, the empirical answer distributions are shown in Fig. 4.2.

The main difference, which becomes apparent from the comparison of the answers, concerns the shape of the distributions. While the question about annual kilometers leads to a single peak distribution, which is scattered around the most common category (5001–10,000 km), the

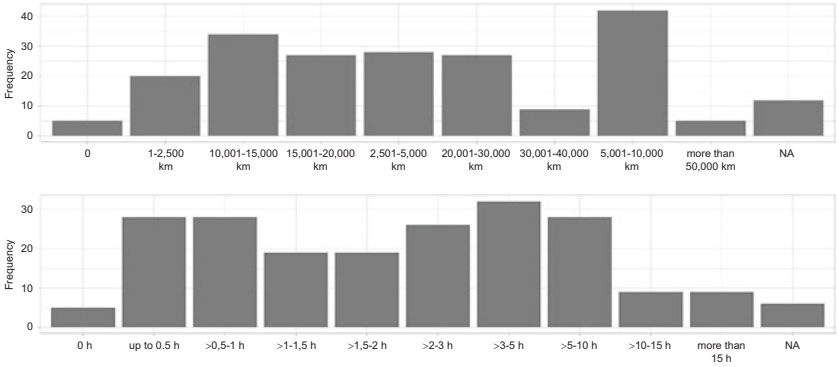

Fig. 4.2 Response distributions (absolute frequencies) for estimation of kilometers driven or hours in a car. (Source: OeNB sample Hadler et al., 2021)

question about hours per week shows two peaks, one in the range between 0.5 and 1 hour and one at 3–5 hours. Both questions seem to have ample answer options in the upper-scale range—that is, for people who travel comparatively often by car. However, in the lower-scale range—for those who use their car infrequently—the question about weekly hours has a second answer category—"up to .5 hours"—that is rather broad. In the very low answer spectrum, this question is therefore less able to differentiate. In part, the differences between the answer distributions are also due to the fact that the distances between the categories are different. For the questions on hours spent, the category width shows a larger spectrum—from 0.5 hours with the second category ("up to .5h") to 5 hours with the tenth category ("> 10–15 h").

However, the two distributions also show similarities. In both cases, five people state that they do not use cars at all. The number of refusals (or "don't know") is slightly higher when asked about kilometers traveled (6% compared to 3%). This is interesting because, initially, it was assumed that the question about the kilometers traveled during the year might be difficult or even impossible to answer for some people. Even though it has been shown that more people do not answer the question about yearly kilometers (12) than about weekly time in the car (6), the level of answers that cannot be used for calculations remains relatively low.

For criteria validation of the car-related questions, the difference between the mileages at both survey points was used as a criterion. At

both points in time (Feb–Mar 2019 and Oct–Dec 2019), the kilometer reading of the most frequently used car was asked. Since it is furthermore possible that a car is also used by others, the second time the survey was conducted, the question was asked as to how often (how many % of the total km) someone else used the car without the respondent him/herself being on board. Then, these answers were used as a weighting factor for the mileage difference between the two points in time to ensure that the result approximates the driven distance when the interviewee was also in the car as a driver or passenger, which is what was asked by the questions to be validated beforehand. So, the question about annual kilometers is refused slightly more often, but it differentiates answers somewhat better, and respondents are more confident in their answers, which is why it seems to work better in surveys in this context.

To check which of the two questions on car use intensity is better suited to approximate the actual behavior, we compared them with an external criterion in the form of the mileage reading difference we had obtained for two dates. Pearson correlation analyses show that there is a strong correlation between the annual kilometer estimate and the kilometer difference ($r = 0.52$, $p < 0.01$). The correlation between the hours per week and the mileage difference is weak and not significant ($r = 0.25$, $p = 0.119$).

Finally, the interviewees were asked how confident they were in their answers for both questions. The comparison of this assessment shows that, on average, people think they are more confident when asked about annual kilometers traveled—63% say they are "very confident" about the accuracy of their answer, while only 44% are confident about the hours per week. Against this background, the assumption that people who are incapable of estimating car kilometers will nonetheless give some kind of answer for reasons of social desirability seems unfounded.

In summary, the question "How many kilometers have you covered in the last 12 months with a car? (as a driver and/or passenger)" can be considered valid according to the information available. It proves to be superior to the question on the time spent per week in a car in three respects. Firstly, the respondents are on average more confident of their answers than with the other question. Secondly, the connection between this question and the validation criterion is stronger than for the hourly question. Finally, considering the content, an argument can be made for the kilometer question because it covers non-routine car usage (e.g., on vacation), which the other question does not.

Alongside car travel, we also surveyed *personal air travel* in several variants. In one variant, the absolute number of flights in the previous year was asked about, distinguishing between different purposes (private and business flights) and distances (short distances up to 3000 km and long distances over 3000 km). Another variant asked about hours spent on an airplane during the previous year. Ten response categories were used, ranging from "0 h" to "more than 50h." As a last variation, there was a question asking which of six statements best describes one's own flight behavior.

Looking at the response distributions, it must be noted that over 50% of all respondents had not taken any flights at all in the previous year. When asked about flight time, many responses were concentrated in the "2.5 h–5 h" category, which roughly corresponds to the flight time of a round trip for a typical summer vacation. The distribution of responses to the question about which statement best describes one's own flying behavior shows that apart from the answer with the highest volume of flights, all other five response categories were chosen by 10–25% of respondents, with the top category being "I fly abroad once every few years."

To get a basis for the validation criterion, the respondents were additionally asked after the regular survey to name the origins and destinations of all flights they had taken in the previous year. Building on that, the average flight times were determined via Google and added. Finally, based on these annual flight times, flight-related CO_2 equivalents, which now serve as a validation indicator, were calculated analogous to the GHG emission calculation described in Chap. 3.

To determine which of the mentioned question variants best approximates flight-based GHG emissions, separate linear regression models[4] (ordinary least squares [OLS]) were calculated and their variance explanations compared. If only the total number of flights is considered, about 67% of the variance was explained (adjusted R^2s). Since intercontinental flights produce significantly more emissions than short-haul flights, it makes sense to make a corresponding distinction. This step increases the proportion of explained variance to 81%. A similar amount of variance, namely 78%, can be explained when the question on the annual flight time

[4]When asked about the number of flights, simply the numeric values (for short- and long-haul flights) were used as predictors. For the categorical question about flight time, the category midpoints were used as numerical values. For the statements, dummies were calculated for five of these statements, and "I never fly" was used as the reference category.

is used. The advantage of this is that only one question is necessary, but it is still possible to somehow differentiate by flight length, which has a strong and direct[5] influence on GHG emissions. However, this question is cognitively rather difficult to answer because, theoretically, all individual flight times must be estimated and added.

Interestingly, the question about individual flight behavior with only six statements as answer categories also explains a quite high proportion of flight-based emissions (48%). The regression analysis shows that the statements ranked according to increasing flight volumes are also associated with correspondingly higher regression coefficients. Compared to the reference category of non-flyers, especially the categories "1 time per year," "several times per year (short distance)," and "several times per year (also long distance)" exert significant influences on the calculated flight-based emissions.

However, the direct comparison shows that this question is significantly worse at approximating GHG impacts than those questions based on a numerical assessment of flight behavior (number of flights or hours). When asked how confident respondents are about their given answers, 88% said they were "very confident" when asked about the number of flights, whereas only 79% of respondents gave this answer when asked about flight hours.

The validity assessment in this section concludes that the two questions about the number of short- and long-distance flights allow the best approximation to the validation criterion. Since these also seem to be somewhat easier to answer than the question about hours in airplanes, they have proven to be the most appropriate here.

Other forms of mobility, such as the use of public transport, bicycle riding, or walking, were not considered as these involve only very small amounts of GHG emissions per person compared with the use of cars or airplanes.

[5] The effect of flight time on flight-based GHG emissions is, of course, mediated by the size of the aircraft, the number of passengers, and the energy efficiency of the engine. However, since these are far from being collected by the questionnaire, they must be left out here.

Diet

Regarding food-based behavior, the interviewees were asked a general question about their meat consumption with answer categories (ranging from "meat in most meals" to "no meat at all"), a question about the frequency of restaurant visits and the like, and a question about what proportion of food they throw away on average. As a validation criterion, the consumption frequency of energy- and resource-intensive foods was surveyed in detail. For example, the frequency of the consumption of different types of meat, fish, cheese, and eggs was asked. Based on this information, CO_2 equivalents were calculated for each person.

It can be seen that those who state that they eat meat only very rarely or live vegetarian or vegan lifestyles have significantly lower nutritional emission values. The difference between those who eat meat in some meals and those who eat meat in most meals is less pronounced. However, it can be seen that it is above all the consumption of sausage and pork in general that decreases the most in people who state that they consume less meat. The consumption of fish, but also beef, on the other hand, decreases less. This is also interesting because it is mainly beef that is associated with particularly high GHG emissions per kg of meat. It seems to be that less exclusive types of meat, such as sausage and pork, are being avoided.

To evaluate how strongly the variable on eating habits affects food-based emissions, an OLS model was calculated, revealing that the answer categories (with "meat in most meals" as the reference category) explain about 32% of the variance (adj. R^2) of food-based emissions. The question about eating habits thus seems to be a useful indicator for the GHG consequences of individual nutrition. However, it was also shown that it is the consumption of special animal foods that is particularly effective here. As an alternative to the question about eating habits, a direct question about the frequency of the consumption of different foods can be used.

The frequency of restaurant visits also shows a certain effect—those who eat out more often have significantly higher emission values because they consume emission-intensive food more often. However, this question can only explain 7% of the variance in food-based emissions, which is why this question is less relevant when it comes to collecting data on GHG emissions.

Consumption

This area includes questions about shopping behavior regarding goods for personal use other than food, which has already been discussed. Here, we deal with the consumption of goods but also with the use of electronics and with leisure activities. The production and transport of such consumer goods generate GHG emissions, which would have to be recorded individually and added up to obtain the individual emission values in this category. However, there are a many sub-categories (e.g., for clothing: shoes, pants, coats, socks, etc.) that are difficult and costly to survey.

With regard to electronics, the respondents were asked to choose one of five statements that most closely correspond to their purchasing behavior of electronic items, ranging from "I don't need most of it" to "I make sure I always have the latest technology." The clothing-related question asked about the respondents' approach to clothing (5 categories, from "very modest" to "always in the latest style").

Since there is no clear external validation criterion here, similar to the diet area, the approach taken was again to use a detailed survey of the consumption frequency of certain important goods. To do this, we surveyed the frequency of purchases of smartphones, laptops, televisions, and so on and asked respondents about the number of shoes, pants, coats, and other clothing categories they purchased in the past year. This information was then in turn used to calculate corresponding GHG emissions.

Looking at the frequency distributions for the electronics variable, it is noticeable that no one chose the extreme category "I make sure I always have the latest technology" and that there is little variation in the responses, with three out of four respondents choosing "I take care to use it for a long time and replace electrical items only when they break." When asked about the use of clothing, there was also no one who answered, "always in the latest style." Here, however, the answers are more strongly distributed among the other categories. Interestingly, the most frequent choice was "long use" and not the always-appealing answer in surveys "average."

With regard to electronics articles, the comparison with the calculated emission quantity (validation criterion) shows that those who say that they "don't need" most electronics products are hardly any different from those who "pay attention to long-term use" and "buy new equipment from time to time." Only those who state that they "regularly" buy new electronics come up with significantly higher emission values. Despite five response categories, this question empirically distinguishes basically just

two levels when it comes to the related emissions (as mentioned, one category was not selected at all). Again, socially desirable response behavior could play a role here. Especially vaguely formulated answer categories allow to choose supposedly "desired" answer categories based on favorable interpretations. This question is ultimately not well suited to survey emissions-related consumption aspects.

While it turns out that the response categories for the question on clothing are relatively well suited to reflect the intensity of the actual purchasing behavior of clothing, the influence on the total GHG emissions from clothing is not particularly strong. This means that there is no strong correlation between personal emissions attributable to clothing purchases and the clothing questions with the five statements.

To get an impression of which of the questions dealt with is best suited to explain the goods consumption-based emissions, regression models were calculated additionally. These models show that the question on clothing has the most explanatory power for this (8% adj. R^2), followed by the question on the use of electronics (7% adj. R^2). However, what also emerges from these calculations is that it is the consumption of "cars" that makes an even more central contribution to explaining these emissions[6] given the impact from the production of an average passenger car, which is estimated to be about seven tons of CO_2 for a small passenger car (Kawamoto et al., 2019). With an average use of a car of ten years (about 40% of the people in the sample say that they buy a car less often than all of ten years), this is still 0.7 tons of CO_2 per year, which can be attributed solely to the production of the car. Accordingly, it is not surprising that the question of how often a new car is purchased contributes even more to explaining the emissions caused by the consumption of goods than those mentioned so far. However, because it is difficult to ask questions about infrequent, large purchases, and because there are also many factors involved in the question about the inventory of vehicles that are difficult to take into account (age of the car at the time of purchase or shared cars), such questions remain difficult in surveys as a source for estimating individual environmental impact.

[6] The share of the explained variance for this variable in the emissions attributable to the consumption of goods is 40% (adj. R^2). Yet, a direct comparability with the other variables mentioned is not given since the purchase frequency of a car is directly included in the calculation of the validation criterion.

4.4 Conclusions and Outlook

This chapter described our questionnaires and samples in detail and presented the results of our validation efforts. Based on various aspects of this validation, we recommend the use of the items on living space, main energy source, thermal insulation, and temperature setting in the area of housing. As for mobility, we recommend asking about the distance traveled by car in the previous year to capture the intensity of car use and to ask separately about the number of short-haul and long-haul flights taken in the previous year to capture personal air travel. In regard to diet, either the use of a general question about dietary habits with formulated statements as response categories or a question about the frequency of the consumption of particularly energy-intensive foods is recommended. For consumption, a question about the purchasing behavior of new clothing can be used to distinguish the largest consumption levels that are relevant in terms of GHG emissions.

So far, we have considered all items and areas separately. The following chapter will look into the question of how to explain the total GHG emissions of our respondents. Firstly, we consider which items are the most suitable for this purpose, with the aim to find a highly parsimonious model. After all, it is not always feasible to include dozens of items on GHG emissions in a single survey, especially when environmental attitudes, sociodemographics, and other items need to be included as well. Secondly, the following chapter will also look into the question as to which factors have the strongest impact on the total GHG emissions of a respondent.

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