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Public Acceptance and Willingness to Pay for Carbon Capture and Utilisation Products

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Abstract: Although the significance of the social science agenda reflecting and affecting the carbon capture and utilisation (CCU) value chain has been acknowledged, there is still a scarcity of research about it. This work contributes in developing an understanding of public perceptions regarding the acceptance, use, and purchasing of carbon dioxide (CO_2)-derived products through an online quantitative survey. Our research suggests the awareness and acceptance of such products are relatively high. Respondents were in favour of CO_2-derived product promotion by policy makers and the industry, approved the funding of such schemes by government, and supported companies that use captured CO_2 in their products. The product category seems to influence the willingness of people to use and buy CO_2-derived products, with our respondents being more willing to use CO_2-derived fuels than food or beverages, showing a caution toward health-related risks. Respondents were also more willing to buy a CO_2-derived product if it was cheaper or better for the environment. Male respondents were in general less willing to pay for CCU-based products, while people aged 25 to 29 were more positive toward them. We conclude that the public will be in favour of CCU-based products and willing to buy them if the involved stakeholders do their part in delivering a safe product at a comparable quality and price to existing ones. Better information provision can also support this cause.

Keywords: carbon capture and utilisation (CCU); carbon dioxide-derived products; public acceptance; awareness; willingness to pay

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1. Introduction

Carbon capture and utilisation (CCU), together with carbon capture and storage (CCS), are widely considered two of the key technologies for mitigating climate change and saving fossil resources at a global level [1,2] by minimising carbon dioxide emissions [3]. The main concept of these two options is the capture of the flue gas stream, emitted by a stationary (in most cases, industrial) point source, and its purification to end up with a carbon dioxide stream of 95–99% purity [4,5]. In the CCS route, this stream can then be transported and stored underground, in either onshore or offshore underground cavities. These could be rock formations, deep saline formations, depleted or active oil and gas fields, or coal beds [6].

In the CCU route, the captured CO_2 stream is instead utilised as a raw material in the production line of another industry or commercial activity to achieve the permanent or temporary storage of CO_2 in the product. These products can be classified in four categories across many industries: (a) direct use, (b) mineral carbonation, (c) fuels production, and (d) chemicals production [7–10]. The products from the 'direct use' category cover a wide range of processes and products and cannot be grouped under a unifying header. They offer temporary storage of CO_2 and involve the utilisation of CO_2 in the food industry (e.g., beverage carbonation, food preservation, coffee decaffeination, water treatment, horticulture as a growth enhancement in greenhouses) and auxiliary industrial uses (e.g., steel manufacture, welding, pulp and paper processing, pneumatics, fire suppression, refrigeration). The 'mineral carbonation' category involves several processes, like calcium carbonate, magnesium carbonate, concrete curing, and bauxite residue treatment, that result in the permanent storage of CO_2 in the mineral and in the case of baking soda production, temporary storage. The end uses belonging to 'fuels production'", as the name indicates, lead to the production of fuels such as methanol, formic acid, synthetic methane gas (SNG), bioethanol and biodiesel through various alternative routes and offer a temporary CO_2 storage option. The category also includes permanent CO_2 storage processes like enhanced oil recovery (EOR) and enhanced coal bed methane recovery (ECBM). Finally, carbon dioxide can be used as a chemical feedstock to produce a wide variety of chemicals with permanent storage or temporary storage (e.g., methanol, formaldehyde, polycarbonates, polyurethanes, organic acids, alcohols, esters, sugars, polyacrylates and urea).

There has been a lot of research on the various stages of a CCU value chain (capture, purification, transportation, and transformation/utilisation), in order to optimise the performance of the value chain as a whole [10–14]. Even if CCU value chains are implemented, the success of their application and commercialisation depends solely on the attitude of customers toward such products for revenue generation. Therefore, the penetration and commercialisation of CO_2-derived products (or captured CO_2 products) to the market is of utmost importance.

However, to make the leap from the theoretical optimisation of the CCU value chain to its wide commercialisation, the stakeholders need to ensure that the final products will be well-accepted by the consumers who would also be willing to purchase them instead of the alternative ones that already exist in the market. This is because, as with any low-carbon transition and climate action mechanism, CCU-based efforts should be pluralistic and inclusive [15], and that can only be achieved if utilisation products 'suit' the potential consumer market. It is thus critical to assess the level of public acceptance of such products by trying to answer the simple, but not simplistic, question: "Would you drink a fizzy drink if the carbon dioxide in it was sourced from the nearby chimney?" or, "Would you sleep on a mattress, the foam of which has been produced using industrially captured carbon dioxide?"

Public opposition could jeopardise the deployment of these CCU-based technologies and products [16], while, at the same time, widespread awareness can teach people that carbon dioxide is the same regardless of where it is sourced. Hence, the manuscript hereafter reviews the existing literature on public acceptance of CCS and CCU in Sections 1.1 and 1.2, and provides a description of the chosen methodology for assessing the consumer's attitude toward CO_2-derived products in Section 2. The results are presented and analysed in Section 3, and the main findings are discussed in Sections 4 and 5.

1.1. Public Acceptance of CCS

CCS, as the more mature of the two options and already implemented on a commercial scale over the last two decades, has been the epicentre of various studies around public acceptance. Already in 2014, L'Orange et al. [17] identified 42 journal articles focusing on public perception of CCS as a novel technology. However, these were mostly on a theoretical basis, with limited samples from regions where CCS was implemented. In most of these cases, CCS faced scepticism or opposition from the public, meaning that much effort was spent in communication to convince them [18,19]. The various parameters examined in CCS public perception studies were supplying information, communication, trust, knowledge, and dissemination, as well as social, political, and cross-cultural factors [20].

Tevetkov et al. [21] reported that public awareness of CCS is low in most of the world, and it is only when people are informed that they change their mind to a neutral/more positive stance. The acceptance is even lower when it comes to the storage location and installation of the infrastructure, where the 'not in my back yard' approach is often more dominant than a potential positive attitude due to the wider environmental benefits. That was also the major finding of Krause et al. [22], who highlighted that 20% of CCS supporters switched to a more negative perception when a CCS facility was proposed to be installed close to their communities. To improve this situation, public engagement is critical [23], since the analysis showed differences in perceptions between those who engage directly with the public and those who do not. This should also be combined with developing trust between public and industry, and attempting to address the perceived risks relating to the safety of CCS projects [24].

1.2. Public Acceptance of CCU

The nature of CCU value chains leads to a different approach compared to CCS, in terms of assessing public perception regarding the long-term viability of such schemes. On one hand, there is the acceptance of CCU as a novel technology, in terms of installation of capture facilities and transportation of the captured CO_2 stream, and on the other hand, there is the acceptance of the final products. These include all the product categories mentioned earlier, which should not only be accepted but also purchased, to create a revenue stream for the participating industries.

In terms of the technological aspect, the main findings related to the implementation of CCS schemes could also be applicable for the CCU ones. Jones et al. [25] conducted a series of exploratory interviews with lay people and concluded that, although the knowledge of and familiarisation with CCU is currently very low (a finding also reported by Perdan et al. [26]), there is a positive inclination within the public and a tentative support for the concept. Linzenich et al. [1] have concluded through an online survey that, even though the evaluation profiles for CCS and CCU were similar, there is overall higher acceptance for CCU compared to CCS. These findings were confirmed by Arning et al. [27], who evaluated the general perception and acceptance of CCS and CCU in Germany through an online survey. They also pointed out that the main factors leading to a negative image of CCS are perceived risks related to CO_2 storage and transportation, whereas the same factors for CCU are perceived to be risks related to CCU products and disposal. In a parallel study, Arning et al. [28] focused even more on these perceived risks, identifying four sub-dimensions; health, product quality, environmental and sustainability risks, with health and environmental risks being highlighted as the most critical factors. Health-related risks are frequently used as an argument against the wider implementation of novel technologies, even if these concerns are not always supported by proof [28,29]. In terms of the sample characteristics, age, gender, and education did not have any impact on public acceptance or risk perception, with the exception of female respondents, who reported a higher risk perception [28].

Since the CO_2-derived products, and more specifically their potential health and environmental impact, are a major factor in the public acceptance of CCU, it is worth further investigating it. Van Heek et al. [30] examined the acceptance of plastic products which have been produced via CCU. A mattress was chosen as a representative example, since it is a product that has already been launched into the market. They followed a dual approach, which combined interviews with experts and lay people, and questionnaires. The main findings were the drivers (disposal conditions, resource savings) and barriers (potential health effects) for the public acceptance of CO_2-derived products. Arning et al. [31] followed up with a socio-demographic study to analyse the consumer profiles and their reaction to CO_2-derived products, again using the foam mattress as the representative case. They have categorised the public in three different categories: approver (32% of the sample; younger, mainly male, technical professional background); cautious (57% of the sample; older, mainly female, working in a non-technical profession); and rejecter (only 11% of the sample, with non-uniform characteristics).

Our study aims to combine the approaches followed by Van Heek et al. [30] and Arning et al. [31], but examine the attitudes of customers toward multiple products. The products have been organised in different categories, with representative examples for each one of those. The categories have not been chosen based on the four end uses of carbon dioxide but on the nature of the final product, since it would be easier for the consumer to assess that. The three defined categories are: (a) fuel (with petrol and bioethanol being the two commodities assessed); (b) household (with mattresses and concrete being the two final products in question); and (c) food (with fizzy drinks, tomatoes, and dietary supplements being assessed for public acceptance). The research objectives refer to: assessing public acceptance and the willingness to pay for these products, assuming that recycled CO_2 was used in their production; identifying any trends among the sample participants; and contextualising the main reasons behind a positive/negative attitude. Moreover, a final topic that was assessed was the attitude of respondents toward the commercialisation of CCU value chains.

2. Materials and Methods

A primarily quantitative survey was employed to identify attitudes toward use/consumption of CO_2-derived products, using captured and recycled CO_2. A questionnaire was developed containing 28 questions, organised in five thematic parts referring to: the respondents' general environmental awareness, focusing on climate change and global warming; their knowledge of CO_2 reuse; their attitudes toward using CO_2-derived products from a variety of industrial sectors; their view on the commercialisation of such products; and the respondents' demographic characteristics. Three of these questions contained seven sub-questions each. Five-point Likert scales were used to record responses varying from 'strongly agree' to 'strongly disagree', with a neutral mid-point. To improve the response rate of the questionnaire, financial incentives and survey introduction notes were utilised, since they have been reported to positively affect the total number of respondents and increase response rates [32]. The incentive was an entry into a prize draw for an Amazon voucher worth £25.

The opening of the questionnaire introduced the concept of carbon dioxide capture and utilisation to the reader, and presented alternative industrial sectors where it could be applied. It was also clarified that the "carbon dioxide can be then cleaned (i.e., purified to an appropriate standard)", to avoid any misconception about potential health issues that might arise from the process. The introduction of the survey also informed readers that the survey was for an academic study and any information provided would be anonymised, and used confidentially and for research purposes only.

There were no questions referring to a specific hypothetical scenario of an optimal carbon dioxide reuse scenario or the ideas of the researcher about the 'right' solution in terms of widely implementing carbon dioxide and reuse. This was an intentional feature of the study so that bias was minimised; we acknowledge, however, the potential for social desirability bias that the self-reporting of individual assessments may have generated.

The questionnaire was available to the wider public in an online form. The online survey was administrated by, and accessible through, the Qualtrics webpage of our university. It was distributed electronically through social media (LinkedIn, Twitter, Facebook), through the university's mailing list (including both academics and researchers), and was also disseminated to the students of the BEng and MEng Chemical Engineering programmes running at our university. It was also sent to selected academics/collaborators in order to share it with their students. Similar previous research actually used samples solely constituted of undergraduate students to avoid recruitment complications and maintain a high understanding of the key attitude object (e.g., [33]). There was also an element of snowballing; participants that filled in the survey were asked to pass it on to people they knew so that the participant pool could increase. Answering the survey was open to all participants able to answer it; we recognise that potentially some people would not be interested or able to complete it, since CCU is not an easily 'accessible' or commonplace agenda. There were no geographical restrictions in recruitment, although our sample is predominately UK-centric, consisting of 266 usable responses. The questionnaire is provided in the Appendix A.

3. Results

The results are grouped according to the five thematic parts in which the questionnaire was organised: the respondents' demographic characteristics; their general environmental awareness; their familiarity with CO_2 reuse; and their attitudes toward using CO_2-recycled products and the commercialisation of such products.

3.1. Demographics

Identifying the profile of the sample in terms of its demographic characteristics is a tool for facilitating more meaningful analytic comparisons and identifying the potential of the sample to be representative of a wider population. Table 1 summarises the collected demographic characteristics of the sample. The gender split of the sample was 54.2% male, 45.3% female and 0.5% other, characterised by slightly increased male share compared to the world population in general (50.5% male, 49.5% female) and the European population (49% male, 51% female), as recorded by the latest Eurostat Census [34].

Table 1. Sample's demographic profile.

Demographic Characteristics	Sample's Specifics	
Gender	Male	54.22%
	Female	45.33%
	Other	0.44%
Age	18–24	29.33%
	25–29	21.33%
	30–39	30.67%
	40–49	14.22%
	50–59	2.22%
	Above 60	2.22%
Educational Background	Primary school	0.44%
	Secondary school	4.44%
	University degree	36.44%
	Master's degree	39.11%
	Doctorate degree	19.56%

The two age groups that were most likely to respond to the survey were the people aged 30–39 (30.6% of the sample) and 18–24 (29.3% of the sample). The latter figure was expected, as the questionnaire was answered by many university students. Only 4.5% of the sample referred to people aged 50 and over, which was not an altogether unlikely outcome. In line with other research studies (i.e., [35]), it can be assumed that people over 50, and especially older people (60+), did not have the opportunity (or access) to reply via the internet-based survey platform, and that the attitude object of the survey (i.e., use/consumption of goods produced using recycled CO_2) was irrelevant, unfamiliar, or complicated to them.

In terms of educational background, the sample of the survey had a significantly higher level (95% had completed tertiary education) compared to that of the European population, which was approximately 35% by the latest Eurostat Census [34]. Again, this was not entirely unexpected due to the recruitment approach and due to the fact that, despite the simplification of terms, an e-survey on the use/consumption of goods produced using recycled CO_2 is still one with a relatively high degree of difficulty to complete. A previous study by Duan [36] on carbon capture and storage acceptance in China similarly attracted many more highly educated respondents; 69% of respondents reported receiving higher education at a rate much higher than that of the entire population (6.6% at the time). However, as will be shown in the next section, the educational background of the respondents did not translate to an increased awareness and knowledge on carbon, capture and utilisation per se.

3.2. Environmental Awareness

To build up an understanding of the respondents' environmental awareness, data were collected about their recycling habits and their familiarisation with the major current environmental issues. The key survey results are summarised in Table 2.

Table 2. Environmental awareness.

Question on Environmental Awareness	Attitude (When 1 = Strongly Disagree and 5 = Strongly Agree)	
I consider myself someone who cares a lot about the environment.	4.13 (SD 0.75)	
Recycling is very important.	4.52 (SD 0.69)	
Do you recycle?	3.81 (SD 0.91)	
Which of the following products do you recycle?	Green bin products	76%
	Batteries	62%
	Glass	65%
	WEEE	48%
	Food/Garden waste	29%
I am well aware of global warming and its consequences.	4.33 (SD 0.69)	
I believe in the concept of global warming.	4.44 (SD 0.73)	
I am well aware that CO_2 enhances global warming.	4.41 (SD 0.77)	

Overall, most of the respondents consider themselves people who care about the environment (86.5%). However, although 95% of the respondents believe that recycling is important, only 67% of them admit recycling on a regular basis ('always' or 'most of the time'). Food waste and WEEE (Waste Electrical and Electronic Equipment) are, as expected, the two streams with the lowest recycling rates, since the infrastructure for their collection is not as widely implemented as those for other streams.

The next set of questions focused specifically on the concept of carbon reuse and utilisation, and the familiarisation of the respondents with these terms. Table 3 provides a synopsis of these answers. It is evident that, despite the high educational level of the respondents and their knowledge about global warming, only half of the respondents (49.8%) were aware that CO_2 can be captured and recycled, and only 11% of them were informed about the severity of the problem and the impact this might have on the production of daily life commodities.

Table 3. Carbon dioxide reuse awareness (yes/no questions).

Question on CCU Awareness	Response Share	
Did you know that CO_2 can be recycled?	Yes	49.8%
	No	50.2%
Did you know that CO_2 is used as a raw material for industrial applications?	Yes	56.5%
	No	43.5%
Did you know that CO_2 is produced from ammonia for use in industrial applications?	Yes	31.2%
	No	68.8%
Did you know that there is a shortage of CO_2 in the UK?	Yes	11.1%
	No	88.9%

3.3. Attitudes toward CO_2-Recycled Products

The third part of the questionnaire focused on the attitudes of the respondents toward buying and using commodities, which were produced using recycled CO_2 instead of conventionally produced. The products examined can be split into three different categories:

- Fuel (petrol, bioethanol)
- Household (mattress, concrete)
- Food (fizzy drink, tomatoes, dietary supplements)

There were also two slightly different questions examining the attitude of consumers toward (a) the selling of such products ("I would see as something positive the selling of the following products") and (b) their preparedness to purchase and consume the same products ("I would consider buying the following products"). The answers are summarised in Tables 4 and 5.

Table 4. Public acceptance of commodities produced using recycled (instead of industrially produced) CO_2.

Commodities	Attitude (When 1 = Strongly Disagree and 5 = Strongly Agree)
Fuel: Petrol for my car	4.42 (SD 0.77)
Fuel: Bioethanol for my car	4.37 (SD 0.77)
Mattress for my bed	4.02 (SD 0.95)
Concrete for my house	4.27 (SD 0.86)
1 kg tomatoes	3.86 (SD 1.05)
1 bottle of fizzy drink	4.00 (SD 0.98)
Dietary supplements	3.73 (SD 1.06)

Table 5. Purchase of commodities produced using recycled (instead of industrially produced) CO_2.

Commodities	Attitude (When 1 = Strongly Disagree and 5 = Strongly Agree)
Fuel: Petrol for my car	4.31 (SD 0.91)
Fuel: Bioethanol for my car	4.25 (SD 0.90)
Mattress for my bed	4.06 (SD 0.96)
Concrete for my house	4.20 (SD 0.91)
1 kg tomatoes	3.79 (SD 1.11)
1 bottle of fizzy drink	3.88 (SD 1.06)
Dietary supplements	3.75 (SD 1.07)

The average acceptance is slightly higher in the first question compared to the second one for almost all products (only for dietary supplements is a reverse trend observed). This shows that consumers are more reluctant to buy these products, even if they can accept their penetration to the market. This is again an expected result; people are more likely to accept or approve a particular product or measure than use it. This was the case with a previous study on bike-sharing in Gothenburg, where although 90% of the respondents approved of the local scheme and wanted to see it expanded, only 25% of the same people ever used it [37].

In terms of the three categories, approximately 85% of the consumers would consider buying fuels that have been produced using recycled CO_2. However, this value drops to 78% for the household-related products and to 65% for food and beverages. This probably links to purity-related issues for the recycled CO_2 stream and the potential health implications these may generate.

Looking at the reasons behind the willingness of the consumers to purchase the recycled CO_2-based products was another theme of our research (Table 6). The consumers would purchase ('agree' and 'strongly agree') such a product if it was cheaper than the conventional ones (88%) and more environmentally friendly (91%). However, this value drops significantly (34%) if the price of the new product's price is higher than the conventional product (which is likely to be the case, especially in the early stages of development). This could be attributed primarily to cost-sensitivity (i.e., people tend to buy the cheapest product if all other comparison parameters are the same), but also to resistance to trying something new and unproven.

Table 6. Purchase of commodities produced using recycled (instead of industrially produced) CO_2.

Question on Purchase	Attitude (When 1 = Strongly Disagree and 5 = Strongly Agree)
I would buy a product made from recycled CO_2 if it was cheaper.	4.19 (SD 0.89)
I would buy a product made from recycled CO_2 even if it was more expensive.	3.10 (SD 0.87)
I would buy products made from recycled CO_2 if I knew it was better for the environment.	4.26 (SD 0.69)

3.4. Commercialisation of CO_2-Derived Products

The last section of the questionnaire evolves around the attitude of the public toward the wider implementation of CCU schemes and the commercialisation of recycled CO_2-based products. The findings are summarised in Table 7. It is evident that the consumers show a willingness to support such schemes, provided that all the other directly involved stakeholders (i.e., industry, government and policy makers) play their role in researching, promoting, supporting and investing in these schemes.

Table 7. Attitude toward the commercialisation of CCU value chains.

Question on Commercialisation	Attitude (When 1 = Strongly Disagree and 5 = Strongly Agree)
I would like industries to promote the recycling of CO_2.	4.54 (SD 0.67)
I think research and development investments using recycled CO_2 are important.	4.50 (SD 0.64)
Policy makers should promote the use of recycled CO_2 in industry.	4.51 (SD 0.63)
I would support companies using recycled CO_2 to make their products.	4.27 (SD 0.69)
I would be in favour of government funding projects for CO_2 recycling.	4.34 (SD 0.77)

3.5. Modelling Results

Following the descriptive analysis, to quantify the relationship between the public acceptance of CO_2-derived products and the variables representing some of the survey key elements that could explain this relationship, a statistical model (Table 8) was developed. Ordinal regression was chosen as the preferred method, employed since it is a generic approach, widely used for the empirical analysis of any ordered, categorical dependent variable. Various models were tested, using a combination of independent variables, but only the best fit is presented that ensures the most relevant, reliable, and robust statistical results in statistical significance and predictive terms (no presence of multicollinearity).

Table 8. Ordinal regression model for the acceptance of recycled CO_2 products.

ExpensiveBin [a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(b)	
								Lower Bound	Upper Bound
2.00	Intercept	−0.790	0.599	1.744	1	0.187			
	[EnvAware = No]	−0.909	0.570	2.54.6	1	0.11	0.403	0.132	1.231
	[EnvAware = Yes]	0 [b]		2.899	0				
	[Recycle = No]	−0.620	0.364		1	0.089	0.538	0.264	1.098
	[Recycle = Yes]	0 [b]		4.636	0				
	[GWAware = No]	−2.301	1.069		1	0.031	0.100	0.012	0.813
	[GWAware = Yes]	0 [b]		0.140	0				
	[CCUAware = No]	0.122	0.327		1	0.708	1.130	0.596	2.145
	[CCUAware = Yes]	0 [b]		1.479	0				
	[CO_2Shortage = No]	−0.632	0.519		1	0.224	0.532	0.192	1.471
	[CO_2Shortage = Yes]	0 [b]		12.211	0				
	[Gender = Female]	1.112	0.318		1	0.000	3.040	1.630	5.673
	[Gender = Male]	0 [b]		0.995	0				
	[Age = 18–24]	0.467	0.468	0.995	1	0.319	1.595	0.637	3.994
	[Age = 25–29]	0.816	0.492	2.752	1	0.097	2.261	0.862	5.930
	[Age = 30–39]	0.125	0.474	0.069	1	0.792	1.133	0.447	2.870
	[Age = Above 40]	0 [b]			0				
	[Education = Doctorate degree]	0.433	0.420	1.063	1	0.303	1.542	0.677	3.516
	[Education = Lower]	0.047	0.372	0.016	1	0.899	1.048	0.506	2.172
	[Education = Master's degree]	0 [b]			0				

[a]. The reference category is: 1.00; [b]. This parameter is set to zero because it is redundant; N = 225, Modelmodel chi-square = 35.492; $p < 0.01$, −2log likelihood = 174.442, Nagelkerke Pseudo $R^2 = 0.202$. Data extracted using IBM SPSS Statistics 26.

The model uses the following as independent variables: the respondents' self-assessment as an environmentally aware citizen; environmental awareness, as expressed by the recycling rate; carbon reuse potential awareness; gender; educational background; and age. The dependent variable was the strictest of the acceptance responses and referred to the respondents' willingness to pay a premium for using recycled CO_2 products. Specifically, the first dependent variable category refers to the 149 respondents that strongly disagreed, disagreed or were neutral to the purchase of recycled CO_2-based products if they were more expensive than conventional ones, while the second refers to 77 respondents strongly agreeing or agreeing with the same argument. An ordinal regression was also attempted using as a dependent variable the responses expressing the public acceptance of commodities produced using recycled CO_2, but the results were ambiguous and did not show any statistical significance.

Since the acceptance of recycled CO_2 products is related to the environmental and climate change awareness of the consumers, the model incorporated five of the variables expressing the level of awareness, starting from the more generic ones (environmental awareness, recycling habits) and progressing to the more case-specific questions (global warming awareness, CCU awareness and CO_2 shortage awareness). For the last two categories, the questionnaire included a series of alternative questions (knowledge of CO_2 uses as a raw material, knowledge about specific CO_2 uses), which gave similar models to that reported in Table 8. However, using a combination of more than one explanatory variable simultaneously, reflecting the different levels of awareness, did not produce statistically significant estimate results (due to the high correlation between them).

Two variable categories were used in the model to reflect the awareness of the respondents: the first refers to the choices 'strongly disagree', 'disagree' and 'neutral' (expressed as 'No' in Table 8), which was the reference variable category, and the second refers to choices 'agree' and 'strongly agree' (expressed as 'Yes' in Table 8). This alternative grouping was necessary because of the small size of the two groups with people negatively oriented toward this notion, which would have given unreliable results. The likelihood of people, who are aware of climate change, to purchase a more expensive but environmentally friendly CO_2-based product, were 10 times higher than those of people that were not aware of climate change issues (v2 = 4.636; $p < 0.05$).

Statistically significant relationships are reported when considering the recycling habits of the respondents. Two variable categories were used in the model to reflect the awareness of the respondents: the first refers to the choices 'never', 'rarely' and 'sometimes' (expressed as 'No' in Table 8), which was the reference variable category, and the second refers to the choices 'always' and 'most of the time' (expressed as 'Yes' in Table 8). The likelihood of people, who are currently recycling, to purchase a more expensive but more environmentally friendly CO_2-based product, were two times higher than those of people who do not recycle (v2 = 2.899; $p < 0.1$). This leads to the conclusion that environmental awareness and education of the public on climate change, and the benefits of waste recycling and reuse, could be a strong factor in promoting the products' public acceptability.

The likelihood of female respondents accepting the CO_2-derived products was three times higher than that of the male respondents (v2 = 5.335; $p < 0.05$), although men were also very likely to agree or strongly agree with the introduction of such products to the market. Finally, age was found to be associated with the acceptability of recycled CO_2-based products. The likelihood of people aged 25–29 showing support were considerably higher compared to the other age groups of respondents, although younger consumers also have a positive attitude toward the introduction of such products to the market.

4. Discussion

4.1. Benchmarking the Key Findings of the Study

The awareness of CCU was relatively low in previous studies by Perdan et al. [26] and Arning et al. [27], where approximately 75% of the respondents reported a limited knowledge of CCU. Perdan et al. [26] conducted a similar survey to assess public awareness and acceptance of carbon capture and utilisation in the UK. Our findings show a similar trend, although the percentages for CCU awareness and positive attitudes toward CCU deployment are higher in our work, possibly because of our sample being more academically minded and educated than those of previous studies.

Of the respondent pool, 51% were aware of CCU, and 85% were in favour of CCU deployment, as expressed by the question on supporting companies using recycled CO_2 in their products (compared to 51% reported in [26]). Our high acceptance rate agrees with the findings of Arning et al. [27], who report an average CCU acceptance of 93%. However, the acceptance rates reflecting the willingness to pay for these products if they are more expensive than their conventional counterparts were found to be significantly less (34%). This showcases that the willingness to pay for CCU-based innovation, which denotes a 'higher', 'purer, and 'more absolute' level of acceptance (thus the choice of using it as the dependent variable in our modelling exercise), was viewed less favourably. Fewer people wanted to 'sacrifice' by paying more for a more climate action-centric product; this means that lowering CCU product costs, to the degree that recycled CO_2 products are genuinely competitively priced compared to their conventional counterparts, is a key parameter for making these products more sellable in real life.

Regarding gender discrepancies observed in our study, our finding that women are more positive toward CO_2-derived products contradicts the findings of Arning et al. [28], who concluded that women are more cautious regarding CCU, or those of Linzenich et al. [1], who found that male respondents are more likely to be supporters of CCU than female ones. Women, according to Arning et al. [38], have higher perceived uncontrollability of CCU risks than men (i.e., women considered the CCU-technology risks less controllable, and thus believed less in CCU's environmental benefits and more in its ecological and health risks). Additionally, Arning et al. [31] introduced three different categories to characterise consumers: approver, cautious, and rejecter. Most of the female respondents were characterised as 'cautious' (54%), indicating a positive attitude but with an understanding of the involved risks. The 'rejecter' group was predominantly male (with a share of 67%).

We surmise that the rising awareness of climate change and the COVID-19 experience, which showcased what a global disruption can be like, could have pushed more women, who have been found to be more appreciative and supportive of novel interventions with pro-social potential than men [39], to be more open to CCU-related products.

In terms of age discrepancies, our study indicated that people aged 25–29 were more positive toward the use of CO_2-derived products. This is in line with the quantitative work of Yang et al. [40], which saw their younger respondents being in general more willing to support CCS than older respondents. Arning et al. [28], on the other hand, indicated that respondents from higher age groups have a inaccurate perception of product quality risks, and this could potentially make them more open to recycled CO_2 products. All the above studies (including ours) agree that the level of education did not have any direct impact (at least one that was statistically significant) on the acceptability of CO_2-derived products.

The literature suggests that the unfamiliarity and low understanding of CCU can be a barrier for CCU deployment, acceptability and willingness to pay for CO_2-derived products [41], thus suggesting the main action should be to better inform the public on CCU [17]. This was also highlighted by Van Heek et al. [30], who stated that perceived knowledge affects the acceptance of CCU products. The environmental factors were the ones that led consumers toward the acceptability and potential purchase of recycled CO_2-based products, whereas concerns about potential health effects were the main barriers. These findings agree with our study, where the difference in the acceptability between food- and non-food-related products indicates the public concerns about the safety of consuming these products. This leads to the conclusion that environmental awareness and education of the public on climate change and the benefits of waste recycling and reuse could be a strong factor in influencing the products' public acceptability.

4.2. Reflective Commentary and Future Research Directions

All social research studies have several limitations that should be mentioned. The sample size is relatively small, and although the study has given reliable results comparable with other similar studies, it should be extended to a wider sample. Moreover, the age and reported educational status of the respondents is not in line with the average population values. The sample of this study is younger and more educated compared with the average consumer, which might lead to skewed and overly positive results. This can be linked to the fact that the questionnaire was online, which means that certain groups of consumers may have been under-represented (e.g., groups with minimal computer skills, who do not browse over the selected distribution networks, and, perhaps, older people). Future research should aim for a more balanced sample where low-skilled people and older people are more adequately represented.

Most of the responses originated from the UK. Not enough answers were collected per geographical location to allow for statistically significant comparisons between countries on public acceptance. Therefore, future research should aim to assess the acceptance patterns and attitudes of various user groups in different countries. Finally, an online questionnaire also leads to self-reported answers, which may add bias to the data that cannot be measured [42]. These responses, which require self-assessment from the respondents' perspective (ranking their awareness on certain environmental topics), add subjectivity, biases and 'illusory superiority' in the responses [35].

5. Conclusions

The importance of cultural issues in CCU deployment has been acknowledged, but research using a social science lens is still lacking [20]. In fact, even though some CCU products are nearing market maturity, systematic study on the acceptance of these products is still in an embryonic phase [43], notwithstanding that social approval and support is required for any carbon transition [44]. This work tries to address this research gap by studying, through a quantitative online survey, the general public's CCU-related awareness and willingness to accept and eventually purchase recycled CO_2 products. The key lesson to be learnt is that awareness of CCU and its links to climate change mitigation are still relatively low, even for a highly educated sample like the one responding to our survey. On the other hand, acceptance of CCU-based products is relatively high (with people being more cautious for consumable products like food and beverage), possibly for environmental reasons. Rates referring to the willingness to pay extra for such a product, however, were significantly lower, meaning that possible environmental benefits and health risks may be less powerful predictors of consuming behaviour than cost; people are ultimately cost-sensitive buyers and make decisions based on market price comparisons. Our respondents were very sympathetic with policy and industry efforts to actively promote and invest in CCU deployment. This positivity could be further promoted by reducing unfamiliarity with the concept and its products, which may be generated by the limited understanding people have about CCU benefit and risk specifics. This can be achieved, in line with Otto and Gross [18], Haug and Sigson [19] and Oltra et al. [41], by communicating more and better custom-tailored messages to the general public that make more obvious the links between CCU and climate action.

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Appendix A

Appendix A.1. Questionnaire Briefing

Dear Sir or Madam,

I am conducting this survey about carbon capture and utilization looking into how society perceives this type of technology. This would help me identify problems and opportunities and propose solutions that would help in its commercialization, which might have the potential of minimising global warming.

This survey is part of my doctoral research, and it would help me immensely if you could take a few minutes to answer the following questionnaire. Any information that you provide will be anonymized and used confidentially and for research purposes only. Access to the data will be strictly limited to myself and my supervisors.

Anyone who takes part in the survey will be entered in a prize draw to win one of four £25 Amazon vouchers.

Please answer the questionnaire after you have read the following briefing on carbon capture.

Carbon dioxide (CO_2) can be captured and recycled, instead of being emitted to the atmosphere from factories, thus minimizing the "Global Warming" effect (i.e., the increase in the average Earth temperature). Carbon dioxide can be then cleaned (i.e., purified to an appropriate standard) and reused as a raw material for another product. This process is called "carbon capture and utilization" and is one strategy to reduce the amount of CO_2 in the atmosphere. Potential candidate carbon dioxide receivers include the following:

- Food & Beverage Industry
- Pharmaceutical Industry
- Energy Generation
- Synthesis of Chemical Products
- Construction Industry
- Solid Waste Treatment and Wastewater Treatment

Appendix A.2. Questionnaire Sections & Questions

Q1a. I consider myself as someone who cares a lot about the environment.

Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

Q1b. Recycling is very important.

Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

Q1c. Do you recycle?

Respond with Never, Rarely, Sometimes, Most of the time, Always

Q1d. Which of the following products do you recycle? (Choose as many options as you think suitable)

Select between Green Bin Products, Batteries, Glass, WEEE, Food/Garden Waste

Q2a. I am well aware of global warming and its consequences.

Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

Q2b. I believe in the concept of global warming.

Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

Q2c. I am well aware that CO_2 enhances global warming.

Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

Q2d. Did you know that CO_2 can be recycled?

Respond with Yes/No

Q2e. Did you know that CO_2 is used as a raw material for industrial applications?

Respond with Yes/No

Q2f. Did you know that CO_2 is produced from ammonia for use in industrial applications?

Respond with Yes/No

Q2g. Did you know that there is a shortage of CO_2 in the UK?

Respond with Yes/No

Q3. I would accept (the selling of) the following products if recycled CO_2 was used in their production process (instead of industrially produced CO_2).

- 1 kg tomatoes
- 1 bottle of fizzy drink
- Fuel: Petrol for my car
- Fuel: Bioethanol for my car
- Mattress for my bed
- Concrete for my house
- Dietary supplements

Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree for each product separately.

Q4. I would consider buying the following products if recycled CO_2 was used in their production process (instead of industrially produced CO_2).

- 1 kg tomatoes
- 1 bottle of fizzy drink
- Fuel: Petrol for my car
- Fuel: Bioethanol for my car
- Mattress for my bed
- Concrete for my house
- Dietary supplements

Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree for each product separately.

Q5. I would consider buying the following products if recycled CO_2 was used in their production process (instead of industrially produced CO_2) for the following reasons.

- 1 kg tomatoes
- 1 bottle of fizzy drink
- Fuel: Petrol for my car
- Fuel: Bioethanol for my car
- Mattress for my bed
- Concrete for my house
- Dietary supplements

Select between Environmental, Financial, Health & Safety, Not Applicable (i.e., would not buy it).

Q6a. I would buy a product made from recycled CO_2 if it was cheaper.

Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

Q6b. I would buy a product made from recycled CO_2 even if it was more expensive.

Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

Q6c. I would buy products made from recycled CO_2 if I knew it was better for the environment.

Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

Q7a. I would like industries to promote the recycling of CO_2.

Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

Q7b. I think research and development investments using recycled CO_2 are important.

Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

Q7c. Policy makers should promote the use of recycled CO_2 in industry.

Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

Q7d. I would support companies using recycled CO_2 to make their products.

Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

Q7e. I would be in favour of government funding projects for CO_2 recycling.
Respond with Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree.
Q8. Gender
Q8. Age
Q8. Education

References

1. Linzenich, A.; Arning, K.; Offerman-van Heek, J.; Ziefle, M. Uncovering attitudes towards carbon capture storage and utilization technologies in Germany: Insights into affective-cognitive evaluations of benefits and risks. *Energy Res. Soc. Sci.* **2019**, *48*, 205–218. [CrossRef]
2. Zhang, S.; Zhuang, Y.; Tao, R.; Liu, L.; Zhang, L.; Du, J. Multi-objective optimization for the deployment of carbon capture utilization and storage supply chain considering economic and environmental performance. *J. Clean. Prod.* **2020**, *270*, 122481. [CrossRef]
3. Yao, X.; Yuan, X.; Su, S.; Lei, M. Economic feasibility analysis of carbon capture technology in steelworks based on system dynamics. *J. Clean. Prod.* **2021**, *322*, 129046. [CrossRef]
4. Porter, R.T.; Farweather, M.; Pourkashanian, M.; Woolley, R.M. The range and level of impurities in CO_2 streams from different carbon capture sources. *Int. J. Greenh. Gas Control* **2015**, *36*, 161–174. [CrossRef]
5. Walspurger, S.; van Dijk, H.A. *EDGAR CO_2 Purity: Type and Quantities of Impurities Related to CO_2 Point Source and Capture Technology: A Literature Study*; Energy research Centre of the Netherlands ECN: Petten, The Netherlands, 2012.
6. Aminu, M.D.; Nabavu, S.A.; Rochelle, C.A.; Manovic, V. A review of development in carbon dioxide storage. *Appl. Energy* **2017**, *208*, 1389–1419. [CrossRef]
7. Pieri, T.; Nikitas, A.; Castillo-Castillo, A.; Angelis-Dimakis, A. Holistic Assessment of Carbon Capture and Utilization Value Chains. *Environments* **2018**, *5*, 108. [CrossRef]
8. Cuellar-Franca, R.M.; Azapagic, A. Carbon capture, storage and utilisation technologies: A critical analysis. *J. CO_2 Util.* **2014**, *9*, 82–102. [CrossRef]
9. Patricio, J.; Angelis-Dimakis, A.; Castillo-Castillo, A.; Kalmykova, Y.; Rosado, L. Method to identify opportunities for CCU at regional level-Matching sources and receivers. *J. CO_2 Util.* **2017**, *22*, 330–345. [CrossRef]
10. IPCC. *Carbon Dioxide Capture and Storage: Capture of CO_2*; Cambridge University Press: New York, NY, USA, 2005.
11. Cole, I.; Corrigan, P.; Sim, S.; Birbillis, N. Corrosion of pipelines used for C2 transport in CCS: Is it a real problem? *Int. J. Greenh. Gas Control* **2011**, *5*, 749–756. [CrossRef]
12. Spigarelli, B.P.; Kawatra, S.K. Opportunities and challenges in carbon dioxide capture. *J. CO_2 Util.* **2013**, *1*, 69–87. [CrossRef]
13. Wettenhall, B.; Race, J.M.; Downie, M.J. The effect of CO_2 Purity on the development of Pipeline Networks for Carbon Capture and storage Schemes. *Int. J. Greenh. Gas Control* **2014**, *30*, 197–211. [CrossRef]
14. de Visser, E.; Hendricks, C.; Barrio, M.; Molnvik, M.J.; de Koeijer, G.; Liljemark, S.; Le Gallo, Y. Dynamis C2 quality recommendations. *Int. J. Greenh. Gas Control* **2008**, *2*, 478–484. [CrossRef]
15. Sovacool, B.K. Who are the victims of low-carbon transitions? Towards a political ecology of climate change mitigation. *Energy Res. Soc. Sci.* **2021**, *73*, 101916. [CrossRef]
16. d'Amore, F.; Lovisotto, L.; Bezzo, F. Introducing social acceptance into the design of CCS supply chains: A case study at a European level. *J. Clean. Prod.* **2020**, *249*, 119337. [CrossRef]
17. L'Orange, S.S.; Dohle, S.; Siergrist, M. Public perception of carbon capture and storage (CCS): A review. *Renew. Sust. Energ. Rev.* **2014**, *38*, 848–863. [CrossRef]
18. Otto, D.; Gross, M. Stuck on coal and persuasion? A critical review of carbon capture and storage communication. *Energy Res. Soc. Sci.* **2021**, *82*, 102306. [CrossRef]
19. Haug, J.K.; Stigson, P. Local Acceptance and Communication as Crucial Elements for Realizing CCS in the Nordic Region. *Energy Procedia* **2016**, *34*, 315–323. [CrossRef]
20. Karimi, F.; Toikka, A.; Hukkinen, J.I. Comparative socio-cultural analysis of risk perception of Carbon Capture and Storage in the European Union. *Energy Res. Soc. Sci.* **2016**, *21*, 114–122. [CrossRef]
21. Tevetkov, P.; Cherepovitsyn, A.; Fedoseev, S. Public perception of carbon capture and storage: A state-of-the-art overview. *Heliyon* **2019**, *5*, e02845. [CrossRef]
22. Krause, R.M.; Carley, S.R.; Warren, D.C.; Rupp, J.A.; Graham, J.D. Not in (or Under) My Backyard: Geographic Proximity and Public Acceptance of Carbon Capture and Storage Facilities. *Risk Anal.* **2013**, *34*, 529–540. [CrossRef]
23. Xenias, D.; Whitmarsh, L. Carbon capture and storage (CCS) experts' attitudes to and experience with public engagement. *Int. J. Greenh. Gas Control* **2018**, *78*, 103–116. [CrossRef]
24. Broecks, K.; Jack, C.; Mors, E.; Boomsma, C.; Shackley, S. How do people perceive carbon capture and storage for industrial processes? Examining factors underlying public opinion in the Netherlands and the United Kingdom. *Energy Res. Soc. Sci.* **2021**, *81*, 102236. [CrossRef]
25. Jones, C.R.; Olfe-Krautlein, B.; Kaklamanou, D. Lay perceptions of Carbon Dioxide Utilisation technologies in the United Kingdom and Germany: An exploratory qualitative interview study. *Energy Res. Soc. Sci.* **2017**, *34*, 283–293. [CrossRef]

26. Perdan, S.; Jones, C.R.; Azapagic, A. Public awareness and acceptance of carbon capture and utilisation in the UK. *Sustain. Prod. Consum.* **2017**, *10*, 74–84. [CrossRef]
27. Arning, K.; Offermann-van Heek, J.; Linzenich, A.; Kaetlhoen, A.; Sternberg, A.; Bardow, A.; Ziefle, M. Same or different? Insights on public perception and acceptance of carbon capture and storage or utilization in Germany. *Energy Policy* **2019**, *125*, 235–249. [CrossRef]
28. Arning, K.; van Heek, J.; Ziefle, M. Risk Perception and Acceptance of CDU Consumer Products in Germany. *Energy Procedia* **2017**, *114*, 7186–7196. [CrossRef]
29. Cotton, M.; Devine-Wright, P. Putting pylons into place: A UK case study of public perspectives on the impacts of high voltage overhead transmission lines. *J. Environ. Plan. Manag.* **2013**, *56*, 1225–1245. [CrossRef]
30. van Heek, J.; Arning, K.; Ziefle, M. Reduce, reuse, recycle: Acceptance of CO_2-utilization for plastic products. *Energy Policy* **2017**, *105*, 53–66. [CrossRef]
31. Arning, K.; van Heek, J.; Ziefle, M. Acceptance profiles for a carbon-derived foam mattress. Exploring and segmenting consumer perceptions of a carbon capture and utilization product. *J. Clean. Prod.* **2018**, *188*, 171–184. [CrossRef]
32. Nikitas, A.; Avineri, E.; Parkhurst, G. Older people's attitudes to road charging: Are they distinctive and what are the implications for policy? *Transp. Plan. Technol.* **2011**, *34*, 87–108. [CrossRef]
33. Wang, M.; Gong, Y.; Wang, S.; Li, Y.; Sun, Y. Promoting support for carbon capture and storage with social norms: Evidence from a randomized controlled trial in China. *Energy Res. Soc. Sci.* **2021**, *74*, 101979. [CrossRef]
34. Eurostat. Educational Attainment Statistics. 2021. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Educational_attainment_statistics#Level_of_educational_attainment_by_age (accessed on 1 July 2021).
35. Nikitas, A.; Vitel, A.E.; Cotet, C. Autonomous vehicles and employment: An urban futures revolution or catastrophe? *Cities* **2021**, *114*, 103203. [CrossRef]
36. Duan, H. The public perspective of carbon capture and storage for CO_2 emission reductions in China. *Energy Policy* **2010**, *38*, 5281–5289. [CrossRef]
37. Nikitas, A.; Wallgren, P.; Rexfelt, O. The paradox of public acceptance of bike sharing in Gothenburg, Eng. *Sustain.* **2016**, *169*, 101–113. [CrossRef]
38. Arning, K.; Offerman-van Heek, J.; Stenberg, A.; Bardow, A.; Ziefle, M. Risk-benefit perceptions and public acceptance of carbon Capture and Utilization. *Environ. Innov. Soc. Transit.* **2020**, *35*, 292–308. [CrossRef]
39. Sochor, J.; Nikitas, A. A Gender Meta-Analysis of Transport Innovation Acceptance: Women Approve Change. In Proceedings of the 51st Annual Universities' Transport Study Group (UTSG) Conference, Leeds, UK, 8–10 July 2019.
40. Yang, L.; Zhang, X.; McAlinden, K.J. The effect of trust on people's acceptance of CCS (carbon capture and storage) technologies: Evidence from a survey in the People's Republic of China. *Energy* **2016**, *96*, 69–79. [CrossRef]
41. Oltra, C.; Sala, R.; Sola, R.; Di Masso, M.; Rowe, G. Lay perceptions of carbon capture and storage technology. *Int. J. Greenh. Gas Control* **2010**, *4*, 698–706. [CrossRef]
42. Fisher, R.J. Social Desirability Bias and the Validity of Indirect Questioning. *J. Consum. Res.* **1993**, *20*, 303–315. [CrossRef]
43. Offerman-van Heek, J.; Arning, K.; Linzenich, A.; Ziefle, M. Trust and Distrust in Carbon Capture and Utilization Industry as Relevant Factors for the Acceptance of Carbon-Based Products. *Front. Energy Res.* **2018**, *6*, 73. [CrossRef]
44. Sun, Y.; Yang, L.; Cai, B.F.; Li, Q. Comparing the explicit and implicit attitudes of energy stakeholders and the public towards carbon capture and storage. *J. Clean. Prod.* **2020**, *254*, 119337. [CrossRef]