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Fear of COVID-19 reinforces climate change beliefs. Evidence from 28 European countries

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1. Introduction

The "health versus wealth" dilemma of the COVID-19 pandemic demonstrates that humanity must learn to deal with complex risks and parallel crises (Mckee and Stuckler, 2020; Philips et al., 2020). The unpredictability caused by unforeseen threats enhances governments' and institutions' ability to adapt; it requires flexible and rapid reactions even when information is lacking (Zhang et al., 2018). Adequate social legitimacy is often essential to make the right government decisions (Christensen et al., 2016), therefore, it is becoming increasingly useful to understand how one problem's appreciation affects people's perceptions of another severe difficulty. As climate change is an urgent global challenge, its comparison with the pandemic offers an opportunity to examine cross-effects.

Before the pandemic, many studies have discussed the drivers that influence people's attitudes to climate change. The results show significant regional differences: while in developed countries perceptions were more influenced by social factors (e.g., values, political orientation, cultural identity), in developing regions, education and experiences (e.g., frequency of extreme weather events) were more dominant (Hoffman, 2011; McCright et al., 2014; Lee et al., 2015; Hornsey et al., 2016; Poortinga et al., 2019; Hao et al., 2020). Empirical evidence suggests that an increase in knowledge to a certain level is necessary for understanding the phenomenon of climate change. Still, then, high knowledge and high levels of education more politically polarizes the attitudes of individuals (Kahan et al., 2012; Shi et al., 2016; Czarnek et al., 2021). Studies have also shown that high personal social capital is a strong predictor of pro-climate behaviour, whereas national carbon dependency tends to inhibit public response to climate change (Hao et al., 2020).

There are two conflicting behavioural explanations for the effect of social shocks on climate attitudes. One approach is the "finite pool of worry" hypothesis that an increase in fear about one factor reduces concerns about other factors (Americans' climate perceptions before and after the 2008 crisis supported the hypothesis) (Weber, 2006; Weber, 2010). An alternative explanation is the "affect generalization", according to which an increase in concern about a threat may raise fears about other dangers (Johnson and Tversky, 1983; Sisco et al., 2020).

The European Parliament surveyed its Member States to plan the recovery fund. The results showed that respondents ranked climate protection spending third (behind health and economic recovery), supporting the "finite pool of worry" idea (European Parliament, 2020). However, research on climate change attitudes has shown no decline in risk perception in either the United States or the United Kingdom,
showing that the hypotheses were not met or that the two effects are nearly equal (Sisco et al., 2020; Leiserowitz et al., 2020; Evenen et al., 2021). It is also unclear whether the potential decline in climate risk perception is due to increased other threats or additional factors. For example, it is conceivable that climate attitudes have changed because people assign lower emissions to decrease their activity (Chen et al., 2020). Another recent study by Gregersen et al. (2022) used data from a representative longitudinal panel data from Norway reported a decrease in climate change worry during the pandemic’s period, although they did not find a correlation between climate change worry and concern about a possible COVID-19 infection, thus concluding that the finite pool of worry mechanism did not play a role. On the contrary, Ecker et al. (2020) found that COVID-19 framings impact support for climate change mitigative action. The results of their experiments have shown that when climate change is framed as a secondary issue (such that climate action needs to take a “back seat” to promote post-pandemic economic recovery) individuals’ climate-change mitigation support is reduced.

This article provides the first cross-national analysis of the relationship between climate change beliefs and COVID-19 attitudes. We draw on data from a nationally representative survey conducted in autumn 2020, including 28,004 respondents from the 27 countries of the European Union and the United Kingdom. We aimed to discover what drives climate change concerns, awareness, attribution scepticism, and perceived impacts during the pandemic’s second wave. Our key individual-level explanatory variable was COVID-19 concerns. Furthermore, we included the number of COVID-19 cases, deaths, and the Oxford COVID-19 government response tracker (OxCGRRT) stringency index on the country-level.

The structure of the article is as follows. After the Introduction, Section 2 details the data used for the study and the statistical analysis methodology. In Section 3, we present our results and the related discussion. Section 4 contains the conclusion. Finally, the article closes with References and Appendices containing the sources and outputs of the analysis.

2. Material and methods

This section contains the data used in this article, the main variables, and the method of statistical analysis.

2.1. Data

2.1.1. Survey

This study used data from a nationally representative survey in 27 member states of the European Union, and the United Kingdom during September–October 2020. One thousand respondents were sampled in each country, with a total of 28,004 interviews. The 28 countries represent approximately 69 % of the European population. Data was collected via computer-assisted telephone interviews (CATI). In most countries, a mobile/landline sampling frame was used. The household samples were drawn with a geographically stratified random sampling procedure, whereas the last birthday method was used for sampling individuals (Salmon and Nichols, 1983). The samples are representative of the population aged 18 or older in age, sex, and region.

In our weighting procedures, we followed a similar approach to the European Social Survey (ESS) (Lynn and Anghelescu, 2018). Post-stratification weights were applied to correct for over-or under-representation, nonresponse, and sampling error. Post-stratification weights were calculated by age group, gender, education, and region. Our main source for population distributions was the European Union Labour Force Survey and the ESS. Additionally, population size weights were calculated to account for population size differences. Similarly, to the ESS, we calculated ‘analysis weights’, which combines post-stratification weights with population size weights.

The questionnaire covered several topics. Respondents were asked about general political attitudes and preferences, economic expectations, their attitudes towards the European Union, the coronavirus pandemic, migration, family, antisemitism, and media. Questions about climate change beliefs were placed in the middle of the questionnaire. The mean total duration of the interviews was 25 min.

2.1.2. Individual-level variables

Climate change beliefs. To assess climate change beliefs (our dependent variables), we used four questions from Round 8 of ESS, which contained a module on ‘Climate Change and Energy’. Respondents were asked about their climate change concerns with the question “How worried are you about climate change?” with responses from 1 (‘Not at all worried’) to 5 (‘Extremely worried’). Climate change awareness was measured with the question ‘You may have heard the idea that the world’s climate is changing due to increases in temperature over the past 100 years. What is your personal opinion on this? Do you think the world’s climate is changing?’ A four-grade scale was used for this question. We recoded the values so that the highest value indicates that the climate is ‘definitely changing’ and the lowest value indicates that it is ‘definitely not changing’. To assess attribution scepticism, the following question was used: ‘Do you think that climate change is caused by natural processes, human activity, or both?’ with a five-grade scale from 1 (‘entirely by natural processes’) to 5 (‘entirely by human activity’). We recoded ‘I don’t think climate change is happening’ responses to 0. The fourth question about climate change beliefs aimed to capture perceptions of its impact by asking respondents ‘How good or bad do you think the impact of climate change will be on people across the world?’. The response scale ranged from 0 (‘Extremely bad’) to 10 (‘Extremely good’). The responses were reverse coded, so that high values indicate negative perceived impact, to unify the four dependent variables in terms of scale direction. We set all ‘Don’t know’ answers to missing (see Appendix E, Supplementary Table 9–11, for descriptive statistics). All variables were then scaled from 0 to 1. When climate change beliefs were used as predictors in our models, we used the grand-mean centred version of these variables. We preferred grand-mean centring above standardization because this only affects the intercepts (Hox et al., 2017). Nevertheless, we applied standardization in additional models.

COVID-19 concerns. Our key individual-level predictor was concerns on the COVID-19 pandemic. Respondents were asked ‘How concerning do you think the problem of the spread of coronavirus pandemic is?’ A four-grade scale was applied with 1 (‘Highly concerning’) to 4 (‘Not concerning at all’). We reverse coded the responses so that higher values indicate deeper concerns.

Political orientation. Left-right identification was measured by asking ‘Which one is closer to your general political outlook, would you say you are?’. Respondents were able to choose from 1 (‘Left of centre’), 2 (‘Centre’), 3 (‘Right of centre’).

Education. At the educational level, country-specific coding was applied during the data collection to capture the different levels of the countries’ educational systems. The country-specific educational level codes were then allocated to the three basic International Standard Classification of Education categories (ISCED) (UNESCO, 2011). These categories were: less than primary, and lower secondary education (levels 0–2); upper secondary and post-secondary non-tertiary education (levels 3 and 4) and tertiary education (levels 5–8). This unified variable of the educational level was used for weighting and analytical purposes.

Age. Age was measured in seven categories: 18–22 years old, 23–30 years old, 31–40 years old, 41–50 years old, 51–60 years old, 61–65 years old, older than 65 years. All individual-level variables were scaled from 0 to 1 and centred around their grand mean.

2.1.3. Country-level variables

COVID-19 cases and COVID-19 deaths. Our first key country-level predictors were the reported average number of total COVID-19 cases and total COVID-19 deaths in the countries. Our daily data source was the dashboard of Johns Hopkins University, Center for Systems Science
and Engineering Coronavirus Resource Center (Dong et al., 2020). We extracted the averages of the total per million COVID-19 cases and total per million COVID-19 related deaths respectively during September 7, 2020, to October 15, 2020, in each country. The variables were then scaled from 0 to 1 and grand-mean centred.

Stringency index. The other COVID-related country-level predictor was the Oxford COVID-19 government response tracker (OxCGRTR) stringency index (Hale et al., 2020). The University of Oxford developed the stringency index. The indicator aimed at capturing the stringency of government responses to the pandemic all over the world systemati-

2.2. Statistical analysis

We fitted four random intercept multilevel models (MLM) for each dependent variable, with individuals (Level 1) nested within countries (Level 2). We followed Czarnek et al. (2021) by choosing linear models. After starting with the Null-models, we included the fixed effects of both the individual- and country-level predictors in Model 1. Our key individual-level predictor was COVID-19 concerns. We further added individual-level control predictors, such as gender, age, and education, as previous studies have found links between these variables and climate change beliefs (Lee et al., 2015; Hornsey et al., 2016; Poortinga et al., 2019; Czarnek et al., 2021; McCright and Dunlap, 2011). The country-level predictors were COVID-19 cases, death counts, and the Oxford stringency index. Other country-level predictors were also added for controlling purposes, namely the HDI, the countries’ CRI, and the support for green and right-wing parties, respectively. These models were fitted to estimate the general impact of the predictors, while the coefficients were held at constant across countries. Two-way in-

3. Results

3.1. Climate change concerns

The first dependent variable was climate change concerns. Deep COVID-19 concerns are strongly associated with serious concerns on climate change (Table 1). This relationship is endorsed by the finding that climate change concerns were greater in the countries where the pandemic affected people’s life more severely (higher stringency index score).

The results shown in Fig. 1. indicate that COVID-19 concerns have a more substantial impact on climate change concerns among individuals with higher attribution scepticism ($b = 0.21$, s.e. = 0.02, CI(0.18, 0.24)) lower belief in the negative impact of climate change ($b = 0.20$, s.e. = 0.02, CI(0.17, 0.23)) and lower educational level ($b = 0.21$, s.e. = 0.01, CI(0.18, 0.23)). On the other hand, high awareness reinforced the impact of COVID-19 concerns on climate change concerns. The improvement in model fit in Model 3 indicates that COVID-19 concerns account for significant variation in climate change concerns ($\chi^2(2) = 61.92, p < 0.001$). To compare the sizes of the effects of the predictors, we refitted the models with standardized predictors. The models involving standardized predictors show that the most important
Table 1
Results of the multilevel models predicting climate change concerns.

|                         | Null Model | Model 1 (Fixed-effects only) | Model 2 (With interactions) | Model 3 (with random slope) |
|-------------------------|------------|------------------------------|-----------------------------|-----------------------------|
|                         | b (se)     | b (se)                       | b (se)                      | b (se)                      |
| Intercept               | 0.585***   | 0.581***                     | 0.581***                    | 0.580***                    |
| Individual-level predictors |          |                              |                             |                             |
| COVID-19 concerns       | 0.215***   | 0.209***                     | 0.189***                    | 0.180***                    |
| Political orientation   | -0.078***  | -0.077***                    | -0.077***                   | -0.077***                   |
| Climate change awareness| 0.452***   | 0.451***                     | 0.453***                    | 0.453***                    |
| Attribution scepticism  | 0.063***   | 0.069***                     | 0.076***                    | 0.076***                    |
| Perceived impact of climate change | 0.085*** | 0.090***                     | 0.089***                    | 0.089***                    |
| Gender (Female)         | 0.016***   | 0.016***                     | 0.017***                    | 0.017***                    |
| Age                     | -0.094***  | -0.092***                    | -0.091**                   | -0.091**                   |
| Education               | -0.023***  | -0.017***                    | -0.014***                   | -0.014***                   |
| Country-level predictors |           |                              |                             |                             |
| Total COVID-19 cases    | 0.013 (0.050) | 0.013 (0.049)       | 0.015 (0.045)               | 0.015 (0.045)               |
| Total COVID-19 deaths   | -0.087 (0.051) | -0.088 (0.051)        | -0.091* (0.046)             | -0.091* (0.046)             |
| Stringency index        | 0.159**    | 0.160**                     | 0.160**                    | 0.160**                    |
| HDI                     | -0.116***  | -0.115***                    | -0.103***                   | -0.103***                   |
| CRI                     | -0.096***  | -0.096***                    | -0.100***                   | -0.100***                   |
| Green party support     | 0.016 (0.037) | 0.016 (0.037)        | -0.002 (0.033)              | -0.002 (0.033)              |
| Right-wing party support| 0.061 (0.046) | 0.063 (0.045)        | 0.083* (0.041)              | 0.083* (0.041)              |
| Random Effects          |            |                              |                             |                             |
| Individual              | 0.07       | 0.05                         | 0.05                        | 0.05                        |
| Country                 | 0.01       | 0.00                         | 0.00                        | 0.00                        |
| COVID-19 concerns       | 0.08       | 0.03                         | 0.03                        | 0.03                        |
| ICC                     | 27,679     | 21,890                       | 21,890                      | 21,890                      |
| Marginal R² / Conditional R² | 0.000 / 0.079  | 0.347 / 0.365    | 0.340 / 0.359               | 0.335 / 0.355               |
| AIC                     | 43,919,194 | 25,080,506                   | 25,005,251                  | 24,947,334                  |
| log-Likelihood          | -21956,597 | -12522,253                   | -12480,625                  | -12449,667                  |

Notes: All independent variables are scaled between 0 and 1 and grand-mean centered, analysis weights were used, * p < 0.05 ** p < 0.01 *** p < 0.001.

Fig. 1. The effect of COVID-19 concerns on climate change concerns for individuals with low and high attribution scepticism (a), and with the low and high level of education (b). Note: Estimates with 95% confidence intervals.
predictor of climate change concerns is climate change awareness (B = 0.10, p < 0.001), the second is COVID-19 concerns (B = 0.05, p < 0.001) and the third is the stringency index (B = 0.04, p < 0.001, Supplementary Table 1).

3.2. Climate change awareness (trend scepticism)

Second, we demonstrate the results of the multilevel models predicting climate change awareness (Supplementary Table 2). We found that climate change awareness is positively associated with COVID-19 concerns, whereas neither the number of COVID-19 cases, deaths, nor the country’s stringency index affected awareness.

We observed significant interactions between COVID-19 concerns and attribution scepticism, climate change concerns, perceived impact and education (Model 2). As shown in Fig. 2, the impact of COVID-19 concerns on awareness was stronger among individuals with less concerns about climate change (b = 0.08, s.e. = 0.02, CI[0.05, 0.11]) and lower belief in the negative impact of climate change (b = 0.07, s.e. = 0.02, CI[0.03, 0.11]). Admittedly those with high concerns and high beliefs in the negative impacts of climate change already had high levels of awareness, thus COVID-19 could not shift their attitudes significantly. The interaction with attribution scepticism and education was weaker and negative. Including a random slope for COVID-19 concerns significantly improved the fit of the model, reinforcing that COVID-19 concerns explain a significant part of the variance of climate change awareness ($\chi^2(2) = 111.64, p < 0.001$). The final model results with standardized predictors show that besides the effect of the other climate change belief related variables, COVID-19 concerns were associated the most with climate change awareness (B = 0.01, p < 0.01, Supplementary Table 3).

3.3. Attribution scepticism

We examined peoples’ beliefs on whether or not climate change is caused by natural processes or human activity (attribution scepticism). The coefficient for COVID-19 concerns is significant and negative, indicating that those highly concerned about COVID-19, were less likely to believe that climate change is human-caused (Supplementary Table 4). The number of COVID cases or deaths in a country were unrelated to attribution scepticism. In contrast, people were more willing to believe that climate change is human-caused in countries where governmental measures to tackle the pandemic were more stringent (higher stringency index score).

The interactive effects shown in Fig. 3 indicate that the impact of COVID-19 concerns on attribution scepticism largely depends on the individual’s climate change beliefs and educational level. The negative association between COVID-19 concerns and attribution scepticism is only present when concerns are high (b = –0.04, s.e. = 0.01, CI[–0.07, –0.01]), and turns positive when concerns are low (b = 0.04, s.e. = 0.02, CI[0.01, 0.07]). Similarly, we found that low belief in climate change’s negative impact moderates the negative effect of COVID-19 concerns on attribution scepticism. However, the interactive effect of awareness was positive and significant. The regression slopes are largely different depending on education. COVID-19 concerns have a negative effect on attribution scepticism among lower educated individuals (b = –0.05, s.e. = 0.01, CI[–0.08, –0.03]), and a positive effect among highly educated individuals (b = 0.04, s.e. = 0.02, CI[0.01, 0.07]). Here, including a random slope for COVID-19 concerns improved model fit as well ($\chi^2(2) = 144.06, p < 0.001$). The impact of COVID-19 concerns on attribution scepticism with standardized predictors was not significant in the final model (Supplementary Table 5).

3.4. Perceived impact of climate change

The last predicted variable was the views on the impact of climate change. Here, we obtained a positive association with COVID-19, meaning that people with deeper COVID-19 concerns were more likely to believe that climate change impacts will be negative (Supplementary Table 6). The country-level COVID related variables did not have a significant impact on this question.

![Fig. 2. The effect of COVID-19 concerns climate change awareness for individuals with low and high climate change concerns (a) and low and high perceived negative impact of climate change (b). Note: Estimates with 95% confidence intervals.](image-url)
We found weaker interactive effects compared to the previous questions (Model 2). However, the regression slope of COVID-19 varied with attribution scepticism. Deep COVID-19 concerns reinforce people’s views on climate change’s negative impacts when attribution scepticism is low ($b = 0.06$, s.e. $= 0.02$, CI$[0.02, 0.10]$). This effect is weaker when attribution scepticism is high ($b = 0.01$, s.e. $= 0.02$, CI$[-0.04, 0.05]$).

The positive effect of COVID-19 concerns on people’s beliefs in the negative impacts of climate change was more pronounced among individuals with a lower level of education ($b = 0.06$, s.e. $= 0.02$, CI$[0.01, 0.10]$), compared to highly educated individuals ($b = -0.02$, s.e. $= 0.02$, CI$[-0.03, 0.06]$). Here, similarly to the previous models, including a random slope for COVID-19 concerns improved model fit ($\chi^2(2) = 221.98$, $p < 0.001$), but the fixed effect of COVID-19 concerns was insignificant both in Model 3, and in the final model with standardized predictors (Supplementary Table 7).

3.5. Country differences and other predictors

The null models’ ICCs indicated that 2–8 % of the total variance in individual-level climate change beliefs is attributable to variation between countries. We plotted the per-country average intercepts and slopes of COVID-19 concerns on the four dependent variables in Fig. 4, and in Supplementary Extended Data Fig. 1–8. These comparisons show that in most countries, the effects’ direction is the same, although with considerable variation in its size. Nevertheless, the results do not offer a clear regional pattern. COVID-19 concerns have the highest impact on people’s concerns in Western European countries, such as the United Kingdom, France or Germany, and Eastern European countries (e.g. Romania, Bulgaria, Poland). The results are similarly mixed regarding the other dependent variables. Altogether, the effect of COVID-19 concerns on climate change beliefs is the strongest in the United Kingdom.

Including fixed effects of individual and country-level predictors vastly improved the models’ fit for all the four dependent variables (see Supplementary Tables). Lastly, we present some of the most important findings of the control variables. On the individual level, females were less aware of climate change, but had a more vital perception of the human cause of climate change and were more concerned about climate change. Interestingly, awareness was lower among young individuals, and attribution scepticism was higher, although they had deeper climate change concerns. As expected, educated individuals were more aware that climate change is occurring and they were more likely to believe that climate change is human-caused. Still, concerns and beliefs on the negative impact of climate change were deeper among lower educated respondents. The effect of left-right identification is strong and consistent. People show less scepticism and higher awareness, concerns, and belief in climate change’s negative impact on the political left.

Concerning the country-level variables, we found lower climate change concerns in the more developed countries (high HDI), whereas HDI did not affect other climate change beliefs. In countries where the Climate Change Index (CRI) was high, individuals were more aware that climate change is occurring, and they were less concerned about climate change. Neither green party support nor right-wing party support was associated with climate change beliefs.

4. Conclusions

This study contributed to understanding how perceptions of the COVID-19 pandemic may have affected people’s climate change beliefs. Based on cross-national survey data from 28 European countries, we found that COVID-19 fears positively affect climate change concerns, awareness, and the perceived negative impact of climate change. Besides the individual attitudes, on the country level, strict government measures tackling the pandemic (high stringency scores) were also associated with deep climate change concerns. Interestingly, government measures to prevent the spread of the virus have had a much more substantial impact on people’s climate attitudes than infection or mortality data.

In contrast, the effect was reversed by attribution scepticism: those who considered the human contribution to climate change to be lower were more likely to have a lower fear of COVID-19. These results show...
that climate change beliefs are complex, just like their relationship with COVID-19 attitudes. High levels of fear and awareness may not necessarily translate to low scepticism in the times of another crisis. A possible explanation for this seemingly contradictive result can be that those with high COVID- and climate change fears may use strategies of denial and attribute climate change to natural causes (which can be interpreted as more optimistic regarding the future outcomes of the crises) in order to relieve the tension of their major concerns or cognitive dissonance (Festinger, 1957). This assumption is supported by the finding that the negative association between COVID-19 concerns and attribution scepticism was only present when climate change concerns were high. Furthermore the negative effect was only present among lower educated individuals who may have fewer tools to cope with increased fear.

We also found that the effect of COVID-19 concerns on climate change concerns was more significant among lower educated individuals and respondents with lower climate change awareness or higher attribution scepticism. These interactive effects were mixed for the other dependent variables.

In contrast to the experience of the 2008 crisis, our findings yielded evidence in support of the "affect generalization" bias and no proof of the "finite pool of worry" hypothesis. There are several possible explanations for the difference, which are promising future research directions. One possible reason is that while the economic crisis of 2008 was socially endogenous, COVID-19, like the threats posed by climate change, is more exogenous. Besides, individuals can develop control strategies for the economy’s existential threat, but they are entirely vulnerable to natural warnings to the virus’s health and climate change. Finally, humanity has a closer economic crisis experience than with uncertain consequences of pandemics and climate change. Lewandowsky et al. (2021) found that British and Americans rather prefer a “progressive” future to a “return to normal” future for recovery from the pandemic. Our findings match well with these results and suggest that the overlap between the two crisis can be beneficial rather than harmful.

Our study was the first to explore the relationship between COVID-19 and climate change perceptions. Given the explorative nature of our study, further research is needed to understand some of our conclusions. First, the observed association between climate change attitudes and COVID-19 fears may not necessarily imply causality due to cross-sectionality of our data. Although, it seems plausible to assume, that the already existing attitudes towards climate change have been influenced by feelings toward a completely new crisis, experimental and longitudinal research is needed to better understand the nature of this association. Other open questions remain regarding the differences in educational level. A possible explanation for the fact that lower educated individuals were more sensitive to the pandemic’s effect is that attitude strength and attitude certainty (Gross et al., 1995) may be lower among these groups. Similarly, more research is needed to understand the different patterns shown by attribution scepticism and why various aspects of climate change beliefs were associated somewhat differently with COVID-19 concerns.

Fig. 4. Predicted per-country average slopes of COVID-19 concerns on climate change concerns with per-country random intercepts.
The results of this study have a significant policy message. According to previous empirical results, high climate change concerns can raise individuals’ support of climate policies and play an essential role in climate action engagement (Bouman et al., 2020). Thus, the positive association we found between COVID-19 and climate change concerns suggests that the pandemic, as a secondary crisis, may indirectly reinforce peoples’ motivation to tackle climate change. Moreover, the virus’s impact is more robust in the lower educated groups, which have traditionally been less supportive of climate policy, as well as among more sceptical and less concerned individuals. Many experts argue that pandemic risk due to climate change related causes will remain high in the future (Di Marco et al., 2020). Our piece of evidence suggests that COVID-19 and other future crisis may offer a promising opportunity for European governments to step up their climate protection efforts in terms of social legitimacy.

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Ádám Stefkovics: Data curation; Formal analysis; Investigation; Methodology; Software; Validation; Visualisation; Roles/Writing – original draft; Writing – review & editing. Oliver Hortay: Conceptualisation; Investigation; Project administration; Resources; Supervision; Roles/Writing – original draft; Writing – review & editing.

Declaration of Competing Interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supporting information
Supplementary data associated with this article can be found in the online version at doi:10.1016/j.envsci.2022.07.029.

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