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Tweeting About a Revolution? A Cross-National Analysis of Tweets on Climate Change During the Rise of "Fridays for Future"

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Supplementary Materials: Code, Data [see Index of Supplementary Materials]

Abstract

In 2018, thanks to the use of social media, the Fridays for Future (FFF) movement brought global attention to climate change. However, in the post-Covid era, the rhetoric of a return to normality seems to have marginalized those issues from the media debate. Looking at the emergence of FFF, the paper applies topic detection to analyze 19,112 tweets on climate change. The emerging contents of social representations are examined in relation to sociocultural (power distance; individualism; uncertainty avoidance; long-term orientation) and structural (level of pollution) factors associated with the country of origin of the tweets. The primary topic among those identified focuses on calls to action, particularly related to the FFF movement. When this topic is absent, others address efforts to mitigate global warming or strategies for adapting to climate change impacts. The main results indicate that tweets from the most polluted countries and from countries high in short-term orientation are more centered on topics concerning a posteriori response to climate change, also denying it as a defense mechanism. This could prevent imagining alternative futures and the projection of concrete means of countering climate change. The study suggests the importance of transcending the on-line and off-line distinction, not only for mobilization but also to form an arena for debate toward social change.

Keywords

climate change, social representations, social anchoring, Fridays for Future, social media

Highlights

- This study explores the cross-national representation of climate change on Twitter (now X) during the rise of the FFF movement, expecting variations based on structural and sociocultural factors associated with different contexts.
- The primary topic identified in the tweets centers on calls to action, particularly related to the FFF movement. In the absence of this topic, other tweets address efforts to mitigate global warming or strategies for adapting to the impacts of climate change.
- Tweets from highly polluted and short-term oriented countries primarily focus on *a posteriori* responses to climate change, including denial as a defense mechanism, hindering the ability to envision alternative futures and develop concrete strategies.

The cognitive, political, and cultural difficulties in grasping the systemic and complex nature of climate change are reflected in the multiplicity of its representations, which vary widely across individual and sociocultural contexts. Moreover, the gaps between exposure to hazards, awareness, and action have been extensively debated in the literature, underscoring the necessity for comprehensive analyses that encompass various factors, including psycho-social and cultural aspects alongside structural ones (Caillaud et al., 2012; Gifford & Nilsson, 2014; Wong-Parodi & Feygina, 2020). At the intersection between diverse levels of analysis, social representation theory (SRT; Moscovici, 1976) stresses the communicative processes and symbolic coping mechanisms triggered by societal challenges. SRT has proven to be a powerful approach in understanding meaning-making and psychosocial processes associated with climate change (Castro, 2006). In particular, climate change and its associated risks have been examined as social constructions elaborated by people positioned within different social and cultural contexts (Joffé, 2003). Moreover, studies conducted within SRT have shown the importance of social anchoring: shared ideas, images, and language about climate change that circulate within specific groups and guide the direction in which their members make sense of the issues at stake and of their own and others' actions (e.g., Bertoldo & Bousfield, 2011; Doue et al., 2020; Fischer et al., 2012).

Nowadays, social media play a pivotal role also with respect to climate change representations: they foster the circulation of existing views of risks, and their transformation through interpersonal communicative interactions (e.g., Kirilenko & Stepchenkova, 2014), as well as serving as a means of organizing collective action (e.g., Belotti et al., 2022; Segerberg & Bennett, 2011). From this viewpoint, social media are a rich source of data for the study of social representations (de Rosa et al., 2021; Sarrica et al., 2018). Moreover, the possibility offered by computational methods to analyze so-called natural language (e.g., posts from social media) can facilitate cross-national studies on the role of worldwide movements in the transformation and emergence of social representations.

The social movement "Fridays for Future" (FFF) is a particular example of the role played by social media in connecting online and offline, and in establishing a cross-national platform of communication and mobilization. Especially in 2018 and 2019, FFF received great media attention and contributed to a worldwide focus on climate change (Belotti et al., 2022).

The present paper aims to look at the topics elaborated on social media and related to FFF, using them to study how representations of climate change and the related risks have been constructed on global-level social media, and in particular, exploring the context-related differences and the role of social anchoring in representations.

Social Construction of Climate Change: Factors of Social Anchoring

Social representations (SRs) are ''systems of knowledge, or forms of common sense, that human subjects draw upon in order to make sense of the world around them and to act toward it in meaningful ways" (Sammut et al., 2015, p. 8). SRs serve several functions, primarily a symbolic coping function that enables groups to provide shared denotations and connotations to socially relevant objects, making them comprehensible and manageable. Contextually, through anchoring and objectification, processes such as naming, content selection, defalcation, or metaphorical assimilation enable ego-defensive, value-expressing, behavior-guiding functions. Finally, once defined, SRs set the boundaries of groups of individuals sharing the same worldviews and serve as guidance in intergroup processes (Wagner et al., 1999).

Clearly, diverse groups bring competing representations into the societal arena (Bauer & Gaskell, 2008) and take different positions with respect to the object of representation. These groups can interact in the effort to resist or dominate others' views. Intergroup conflicts (as well as policies and societal changes) can affect stability and transformation in representations, introducing veritable turning points. In this regard, Moscovici (1988) identified three different typologies of representations that contribute to the dynamic of change and stability at the societal level: a) hegemonic representations, that are widely shared and accepted by all members of a structured group; b) emancipated representations, that are initially characteristic of subgroups and then emerge as actual challenges to shared visions and common sense; and c) polemical representations, which are marked by controversy and remain a source of conflict and antagonism across groups.

In this view, the variability of social representations of climate change among groups can be explained by their social anchoring in the sociocultural and structural factors that characterize such groups. Among the main factors contributing to this positioning, research has underlined the exposure to hazards (Cori et al., 2020), social and cultural processes (e.g., identity, social norms; Wong-Parodi & Feygina, 2020), and the distance from the object of representation, (i.e., relevance, involvement, knowledge, as well as practices associated with the issue at stake; Dany et al., 2014).

A review conducted by Cori et al. (2020) indicates a relation between structural factors, specifically air pollution, and risk perception: 20 out of the 38 studies reviewed showed a direct association between exposure to polluted air and risk perception. The nature of this connection can be interpreted through the lenses of SRT and the conceptualization of the distance from the object within the same theory. Indeed, SR literature suggests that individuals perceiving a representational object as close emphasize functional components, concentrating on instrumental relations and descriptive characteristics associated with it. Those perceiving a representational object as distant emphasize normative components, highlighting group values, norms, and stereotypes (Dany et al., 2014; cf. also results from Bertoldo & Bousfield, 2011). The same literature also suggests that when faced with something experienced as very threatening, distancing oneself from what is perceived as alarming and catastrophic may serve as a coping mechanism, leading to forms of denial (Joffé, 1999).

At a cultural and cross-cultural level, despite being rooted in different perspectives, Karimi and Toikka (2014) showed that Hofstede's cultural dimensions (Hofstede et al., 2010) affected the risk acceptance of carbon capture and storage technology. Nagy and Konyha (2018) demonstrated that among Hofstede's six cultural dimensions, individualism and power distance have an impact on pro-environmental behavior. Matanggaran and Gutteling (2021) showed that the extent to which people perceive the severity of climate change is correlated to the cultural dimensions of uncertainty avoidance, collectivism, and long-term orientation. The time dimension to understanding responses to climate change is also considered a key point (Pahl et al., 2014), and Zhu et al. (2020) showed that both national and individual differences in future orientation affect climate perception and mitigation.

The above-mentioned studies align with research conducted within Social Representation Theory (SRT) and focused on cross-national comparison. For instance, Fischer et al. (2012) explored social representations of climate change, energy, and the future across five European countries (Hungary, Germany, Scotland, the Czech Republic, and the Netherlands). Alongside a consensus on the unsustainability of resource use, they observed differences related to participants' countries of origin, particularly concerning the affective and normative dimensions of the representations. For example, they stated that in the Scottish and Dutch regions, feelings of guilt and moral opinions were strongly associated with individual behavior, whereas in other countries, normative ideas were primarily linked to the actions of others. Caillaud et al. (2012) showed different representations of the Bali climate conference fostered by German and French media, anchored to human and political categories, and to political and financial categories respectively. They suggest that these differences might be linked to the peculiar histories of green movements in the two countries. Doue et al. (2020), in their examination of climate change risks in two coastal areas (Guadeloupe and Colombia), identified specific differences in psychological, social, and cultural anchoring unique to each region. In

Guadeloupe, sociopolitical anchoring and a global perspective suggest a representation that is more normative and abstract, characterized by a limited practical orientation. In contrast, in Colombia, the conceptualization of climate change through the more practical concept of pollution suggests that the population approaches the issue with a more tangible and action-oriented concept. Bertoldo and Bousfield (2011) considered that changes in the representation of climate change, in turn influencing collective action, can depend upon the context and found that they can be easier to effect where the implications of risks from climate change are greater.

To sum up, the studies mentioned above—among many others—show structural and sociocultural variations in the representations of climate change. However, in an increasingly online society, when studying the representation of a highly debated phenomenon, it is crucial to consider the emergence of cross-national social movements and the impact that social media has in creating a globally interconnected communication landscape. The interplay between local context and global movements, facilitated by social media, adds a layer of complexity to our understanding of cross-national commonalities and differences in the representations of climate change.

The Role of Social Media in the Social Construction of Climate Change

In the case of climate change, mass media play a pivotal role in the initial involvement and in translating scientific findings for the layperson (Joffé, 2003). In this regard, Polli and Camargo (2015) observed that the changes in the way people related to the environment from the 1960s until the early 2010s followed the representations of the environment in the print media, showing that media reflect the society paradigm shifts (from a local to more global thinking).

Today, together with traditional media, online communication enables shared discourse on a global level, which then plays a role in the elaboration and diffusion of SRs or, for existing SRs, serves as a driver for either stability or change. In this scenario, on-line collective movements purposely use social media to foster change by negotiating or contesting existing representations among individuals, groups, and institutions (Batel & Castro, 2015). Social media challenge the traditional media hierarchies, making it possible to observe the development of communication over multiple levels, with different combinations of contextual factors and societal levels (Sarrica et al., 2018). The Twitter social platform (now X), in particular, combines top-down and bottom-up communication, circulating messages from institutions and commercial mass media, but also permitting communications and interactions directly among individual users, who comment and debate, but also compare and even organize practices and actions (Segerberg & Bennett, 2011). Social media in general allow individuals entry into a digital space as users, where they access information from a great variety of sources. This role extends to that of "prousers", who produce and co-produce content with others. Social

media enable the creation of virtual networks wherein people can interact with each other with fewer constraints regarding time (messages, files, and pieces of information can be shared and spread almost instantly) and space (people can interact even if they are physically distant). Activists and others can join such virtual networks in very large numbers, thereby creating and organizing large intercultural communities based on shared interests, values, and characteristics (Fuchs & Sandoval, 2014).

It is important to note that, in general, discourses in the on-line environment are not confined to this sole social arena. The distinction between on-line and off-line, which was relevant in the early phases of the internet, seems to have passed. In ubiquitous contexts of internet connection, there has been an emergence of spaces bridging the physical and virtual spheres, in what is called the "inter-reality" (Riva, 2017). On-line discourses tend to mirror off-line discourses: on the one hand, the needs of people, mass culture, political agenda, and societal events influence the topics and contents dealt with in on-line media (Vliegenthart & Roggeband, 2007); on the other hand, on-line topics can influence or even set political and discursive agendas. Furthermore, researchers have found that texts mined from Twitter can be used to predict features of the off-line world, such as stock market trends (Bollen et al., 2011) or election outcomes (Tumasjan et al., 2011).

Such impacts are observed in climate change-related discourse, where social media have not only increased attention to climate change issues but have also become a virtual forum for the organization of protest movements and a means for "calls to action". In particular, the FFF movement is exemplary of the potential roles of social media in organizing global movements on climate change. Especially in the years 2018–2020, FFF was able to virtually connect a new generation of teenagers and young adults and then bring them into the streets and political spheres (Belotti et al., 2022; Suitner et al., 2023).

Aim

The particularity of the FFF use of social media brought global attention to the phenomenon of climate change, yet, drawing upon the examined literature, we may expect that SRs vary across national and cultural contexts. The present contribution explores the on-line construction of climate change representation by answering these two interconnected research questions: 1) during the period of peak FFF activity, what themes concerning climate change were shared on social media (particularly Twitter[1])? 2) Did these themes vary between countries, and were they anchored in structural and sociocultural factors linked to the different contexts?

1) At the time the data was collected, the social media platform was known as Twitter; it is now called X.

Method

Data Collection

A corpus of English language tweets posted during a peak period of organization of FFF protests (from 18 February to 10 October 2019), featuring the hashtag #climate, with the addition of further hashtags as these emerged (e.g., #climateaction, #climatechange, #extintionrebellion) was collected using the rtweet R package (Kearney, 2019). The period chosen for data collection covers most of the strikes that occurred from the emergence of the movement (except for the first one that occurred in November 2018, which was more isolated)[2] until the end of the study. Indeed, previous research (Suitner et al., 2023) reported that during 2019 the discussion around climate change-oriented collective actions was particularly central in the online discourse around environmental climate, with #FridayforFuture movement being one of the most relevant social actors. In other words, we chose to focus on this specific movement and in this specific period precisely because it has initiated a wave of climate activism on a global scale and for its utilization of social media.

We chose Twitter as it is one of the largest microblogging services which allows monitoring of major world-wide events (Kirilenko & Stepchenkova, 2014) and has been used by the FFF movement for both organizational and sharing purposes. Of the 21,042 tweets collected, the analysis then focused on a sub-corpus containing 19,112 tweets (90% of the total) geolocated in the countries originating the most tweets[3] (Table 1), i.e., excluding those from countries without tweets sufficient for readable analysis.

Table 1

Tweets Distribution in the Sub-Corpus

Country	Number of tweets	Percentage of tweets	Cumulative percentage of tweets
United States	6,847	32.54	32.54
United Kingdom	3,123	14.84	47.38
Canada	2,921	13.88	61.26
Australia	1,285	6.11	67.37
India	834	3.96	71.33
Ireland	666	3.17	74.50
Germany	504	2.40	76.89
Italy	370	1.76	78.65
Belgium	302	1.44	80.09

2) https://fridaysforfuture.org/what-we-do/strike-statistics/list-of-countries/

3) We collected tweets originally posted in English, resulting in an anticipated overrepresentation of English-speaking countries.

Country	Number of tweets	Percentage of tweets	Cumulative percentage of tweets
Nigeria	293	1.39	81.48
New Zealand	258	1.23	82.71
France	205	0.97	83.68
The Netherlands	204	0.97	84.65
Kenya	199	0.95	85.60
Not determined[a]	176	0.84	86.43
Spain	171	0.81	87.24
Sweden	163	0.77	88.02
Switzerland	148	0.70	88.72
Austria	140	0.67	89.39
Finland	130	0.62	90.01
Ghana	121	0.58	90.58
Pakistan	120	0.57	91.15
Denmark	108	0.51	91.66

[a]Tweets not attributable to any country were not considered.

Table 2 shows the lexicometric measures calculated to assess the applicability of analyses relying on word counts (bag of words). The ratio of total occurrences (word token) to the number of distinct forms (word type) is within the recommended ceiling of 20% (Bolasco, 2013). Hapax legomena (words that appear only once) exceed 50%, however, this rate is not uncommon in a corpus composed of texts that may include slang and grammatical errors (cf. Rizzoli et al., 2021). Overall, the corpus can be considered adequate for this type of analysis.

Table 2

Lexicometric Measures of the Sub-Corpus

N - Token	480,193
V - Type	44,556
(V/N)*100 - Type/token ratio	9.28
(V1/V)*100 - Hapax legomena	60.27

Corpus Pre-Processing and Multiword Identification

The sub-corpus composed of 90% of tweets was pre-processed using TaLTaC2 software (Version 2.10.2; Bolasco et al., 2000). Upper case was converted to lowercase letters. Multi-words (informative word sequences) with frequencies ≥ 5 within the corpus were also automatically identified (Pavone, 2018), then manually checked for acceptance, and considered as textual units.

Sociocultural and Structural Factors as Variables for Social Anchoring

Based on the existing literature, we selected sociocultural along with structural factors potentially linked to the representation of climate change (i.e., that could serve as variables for social anchoring). Each tweet was associated with the corresponding modality of the contextual variables, based on the country of origin identified through geolocation. These variables include structural factors (linked to the territory) and sociocultural factors (i.e., reflecting the orientation along sociocultural constructs of the population living in the territory).

Level of Pollution of the Country (Structural Factor)

The level of pollution of each country is given by the measure of emissions of metric tons of carbon dioxide equivalent (MTCO2)[4], a metric often used to compare countries in terms of emissions of different greenhouse gasses with potential for global warming. Each country is assigned a score representing the total MTCO2 emissions. This score was then utilized to categorize countries into four groups based on quartiles: those with higher scores are classified as having a "high pollution level"; those in the third quartile are labeled as "medium-high level"; those in the second quartile are categorized as "medium-low level"; and those in the first quartile are placed in the "low pollution level" (see Table A1). This variable was chosen because pollution exposure can influence perception (Cori et al., 2020) and, therefore, how a risk phenomenon related to environmental issues, such as climate change, is represented. According to the literature (Dany et al., 2014), when issues related to climate change are experienced as distant (i.e., not concerning oneself or one's reference group; lower pollution level), we should anticipate distinct representational content compared to when they are experienced as close (higher pollution level). Moreover, we may anticipate that increased proximity to climate change issues could affect its representation leading to forms of denial as a dysfunctional coping mechanism for something perceived as excessively threatening (Joffé, 1999).

Power Distance; Individualism; Uncertainty Avoidance; Long-Term Orientation (Sociocultural Factors)

Four of six factors of the Culture Compass 6D-Model[5] were chosen, based on their possible links with representations about climate change (Matanggaran & Gutteling, 2021; Slawinski et al., 2017; Wong-Parodi & Feygina, 2020). This model was selected because it is already established in the literature and because it offers an index that is

4) Data obtained from http://www.globalcarbonatlas.org/en/CO2-emissions. Data refer to the period 1960–2017 and updated to 2019.

5) https://hi.hofstede-insights.com/national-culture

based on the country of origin (e.g., Karimi & Toikka, 2014; Matanggaran & Gutteling, 2021; Nagy & Konyha, 2018). The four factors chosen were: *power distance*, expressing the extent to which the people of the country recognize and accept inequalities of power distributions; *individualism*, expressing the tendency to worry mainly about oneself and one's surrounding people, rather than the society of belonging (collectivism); *uncertainty avoidance*, representing the degree to which people feel comfortable versus uncomfortable with uncertainty and ambiguity concerning the future; *long-term orientation* represents the preference for engaging in education for the future rather than the preference for maintaining the status quo. As with the structural factor, the countries were divided into high, medium-high, medium-low, and low levels with respect to each of the sociocultural factors (Table A1).

Each tweet was also associated with the *month* and *day* of the week of posting and the *country* of origin. Regarding these variables, we have expectations concerning the number of tweets; specifically, we anticipate a higher quantity during periods proximate to strikes (e.g., Fridays) and in English-speaking countries, given the language of the tweets collected. Furthermore, concerning topics, we expect to observe more organizational-related content during periods surrounding the strikes.

Analyses

To answer the first research question (i.e., what themes concerning climate change are shared on Twitter during the period of peak FFF activity), the sub-corpus of geolocated tweets was analyzed by the Reinert method implemented in the Iramuteq R interface (Ratinaud, 2009). The Reinert method is a topic detection technique widely used in the field of SRs. Through a hierarchical descending classification, clusters of words that define a topic are identified. They result from the calculation of the co-occurrences of words in text portions (elementary context units) in which the software subdivides each text (initial context unit). Given the limited length of the tweets, in this case, the elementary context units correspond to the whole tweet (i.e., the initial context units). According to this approach, the recurrence of a series of words in a portion of the text is a trace of an underlying place of thought, and the more frequent it is, the more distinctive it will be of a topic (Reinert, 1993). Therefore, observing the set of words in the clusters and these words in their context of use (the tweets) through the concordance analysis, it is possible to label the clusters, and thus identify the main themes addressed within a corpus, that is, the content of the representation. In addition to providing lists of words most characteristic of each cluster, this analysis also yields an association score between text portions (i.e., tweets) and the clusters, thereby classifying the tweets in relation to the emerged clusters.

To answer the second research question (i.e., how are the themes anchored in sociocultural and structural factors), the degree of association (chi-square index) between each cluster obtained and the modes of each variable considered (day, month, country, mtco2,

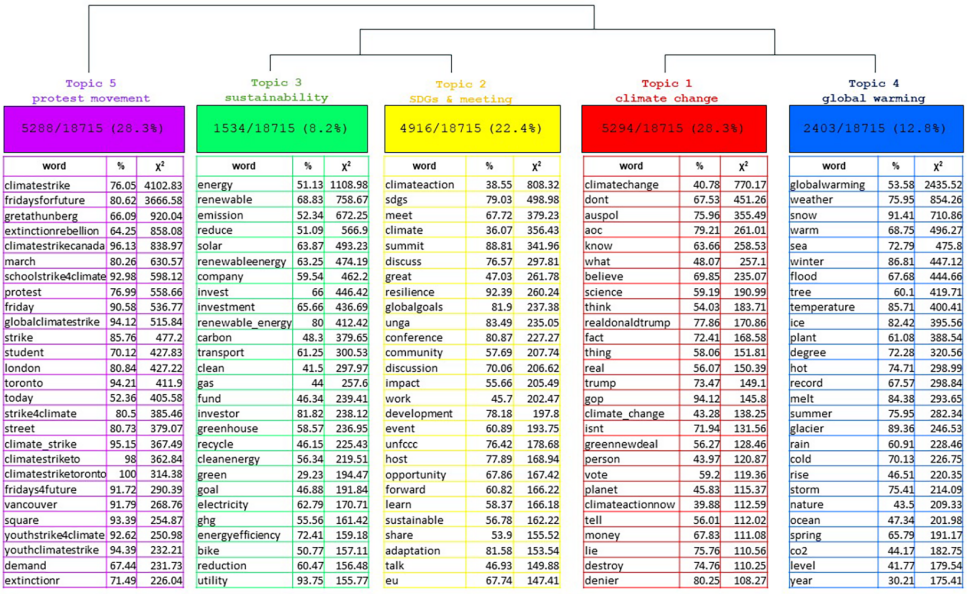
power distance, individualism, uncertainty avoidance, long-term orientation) were calculated through Iramuteq and displayed using the software R. This last step allows observation of how the themes shared in tweets vary with the physical and sociocultural context of the posting person, thereby revealing whether there are differences in representation according to the reference context.

Results

The Reinert method individuated five clusters (Figure 1), comprising a 98% share of all the classified tweets (18,715 out of 19,112).

Figure 1

Dendrogram of the Five Clusters Identified with the Reinert Method



word	%	χ^2
climatestrike	76.05	4102.83
fridaysforfuture	80.62	3666.58
gretathunberg	66.09	920.04
extinctionrebellion	64.25	858.08
climatestrikecanada	96.13	838.97
march	80.26	630.57
schoolstrike4climate	92.98	598.12
protest	76.99	558.66
friday	90.58	536.77
globalclimatestrike	94.12	515.84
strike	85.76	477.2
student	70.12	427.83
london	80.84	427.22
toronto	94.21	411.9
today	52.36	405.58
strike4climate	80.5	385.46
street	80.73	379.07
climate_strike	95.15	367.49
climatestriketo	98	362.84
climatestriketoronto	100	314.38
fridays4future	91.72	290.39
vancouver	91.79	268.76
square	93.39	254.87
youthstrike4climate	92.62	250.98
youthclimatestrike	94.39	232.21
demand	67.44	231.73
extinctionr	71.49	226.04

word	%	χ^2
energy	51.13	1108.98
renewable	68.83	758.67
emission	52.34	672.25
reduce	51.09	566.9
solar	63.87	493.23
renewableenergy	63.25	474.19
company	59.54	462.2
invest	66	446.42
investment	65.66	436.69
renewable_energy	80	412.42
carbon	48.3	379.65
transport	61.25	300.53
clean	41.5	297.97
gas	44	257.6
fund	46.34	239.41
investor	81.82	238.12
greenhouse	58.57	236.95
recycle	46.15	225.43
cleanenergy	56.34	219.51
green	29.23	194.47
goal	46.88	191.84
electricity	62.79	170.71
ghg	55.56	161.42
energyefficiency	72.41	159.18
bike	50.77	157.11
reduction	60.47	156.48
utility	93.75	155.77

word	%	χ^2
climateaction	38.55	808.32
sdgs	79.03	498.98
meet	67.72	379.23
climate	36.07	356.43
summit	88.81	341.96
discuss	76.57	297.81
great	47.03	261.78
resilience	92.39	260.24
globalgoals	81.9	237.38
unga	83.49	235.05
conference	80.87	227.27
community	57.69	207.74
discussion	70.06	206.62
impact	55.66	205.49
work	45.7	202.47
development	78.18	197.8
event	60.89	193.75
unfccc	76.42	178.68
host	77.89	168.94
opportunity	67.86	167.42
forward	60.82	166.22
learn	58.37	166.18
sustainable	56.78	162.22
share	53.9	155.52
adaptation	81.58	153.54
talk	46.93	149.88
eu	67.74	147.41

word	%	χ^2
climatechange	40.78	770.17
dont	67.53	451.26
auspol	75.96	355.49
aoc	79.21	261.01
know	63.66	258.53
what	48.07	257.1
believe	69.85	235.07
science	59.19	190.99
think	54.03	183.71
realdonaldtrump	77.86	170.86
fact	72.41	168.58
thing	58.06	151.81
real	56.07	150.39
trump	73.47	149.1
gop	94.12	145.8
climate_change	43.28	138.25
isnt	71.94	131.56
greennewdeal	56.27	128.46
person	43.97	120.87
vote	59.2	119.36
planet	45.83	115.37
climateactionnow	39.88	112.59
tell	56.01	112.02
money	67.83	111.08
lie	75.76	110.56
destroy	74.76	110.25
denier	80.25	108.27

word	%	χ^2
globalwarming	53.58	2435.52
weather	75.95	854.26
snow	91.41	710.86
warm	68.75	496.27
sea	72.79	475.8
winter	86.81	447.12
flood	67.68	444.66
tree	60.1	419.71
temperature	85.71	400.41
ice	82.42	395.56
plant	61.08	388.54
degree	72.28	320.56
hot	74.71	298.99
record	67.57	298.84
melt	84.38	293.65
summer	75.95	282.34
glacier	89.36	246.53
rain	60.91	228.46
cold	70.13	226.75
rise	46.51	220.35
storm	75.41	214.09
nature	43.5	209.33
ocean	47.34	201.98
spring	65.79	191.17
co2	44.17	182.75
level	41.77	179.54
year	30.21	175.41

Note. % = percentage of word occurrence on the text segments of the cluster in relation to its occurrence in the corpus. All the displayed words are associated with p-value < .0001.

The first split separated cluster 5 (label: *protest movement*) from the others: a cluster comprising 28.3% of the classified tweets, related to the FFF protest movement. The most associated words refer to the organization of strikes, marches, and other protest actions, particularly FFF, in favor of policy and intervention on climate change. The tweets classified in this cluster include mainly slogans, for example: “There is no planet b #climatestrike #chicago” or “weve got the whole world in our hands #climatestrike”.

The second split divided the remaining four clusters into two subgroups: one containing Clusters 2 and 3, whose themes refer mostly to climate change mitigation (in terms of efforts to reduce or prevent global warming); the other containing Clusters 1 and 4, whose themes refer most to adaptation strategies (in terms of adjusting or react to—also denying as a defense mechanism—the impacts of climate change).

More specifically, Cluster 2 (22.4% of classified tweets, label: *SDGs & meeting*) contains words referring to calls for action, sustainable development goals, and major meetings on climate change with an emphasis on policies. Examples of the tweets in this cluster would be "lets change #climatechange by building a better future for all by taking #climateaction now" and "this is bad for business bad for the future #breakfreefromplastc #act4sdgs #act4climate #climateaction #climatejustice".

Cluster 3 (8.2% of the classified tweets, label: *sustainability*) includes words related to green economy and sustainability, with particular reference to renewable energy, emissions, and transport. Among the tweets resulting in this cluster: "theres a very close correlation with energy consumption and carbon emission theres no way to industrialise a nation without increasing #climatechange we can only limit emissions #africaclimateweek #climateaction #aracewecanwin #savetheworld".

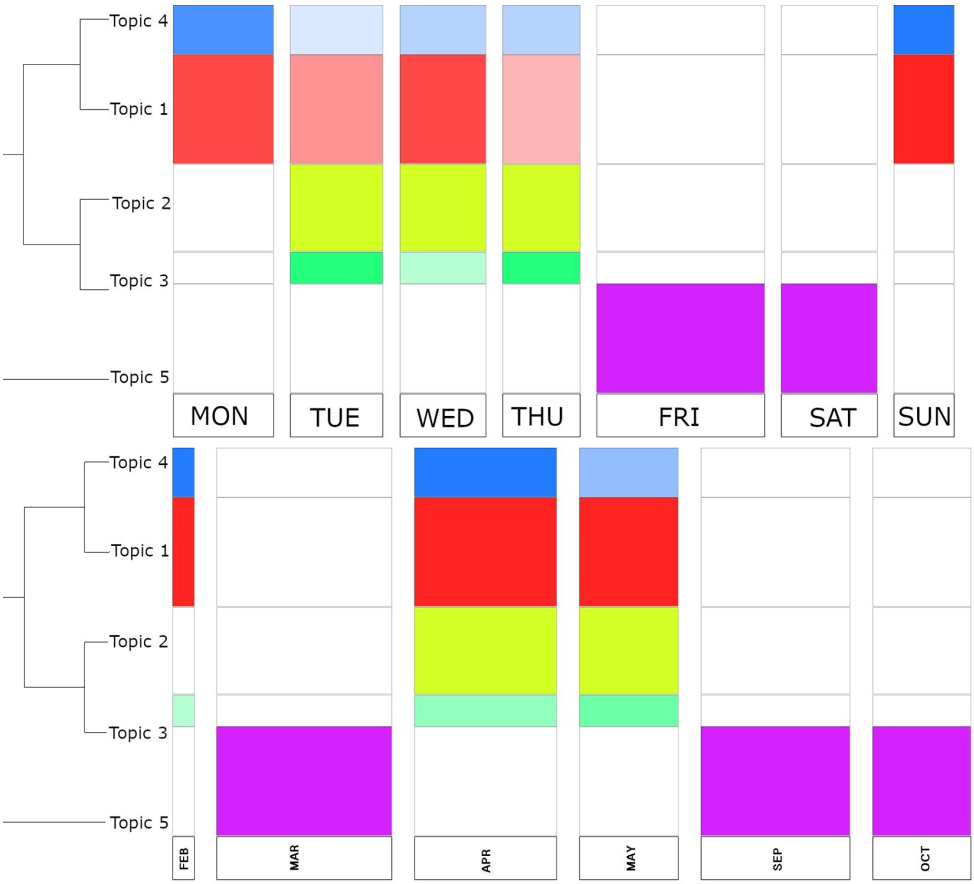
Regarding the clusters on adaptation strategies, Cluster 1 (28.3% of the classified tweets, label: *climate change*) contains politically connoted climate change-related words, also with references to climate change denial, principally in terms of criticism of political class deniers, for example: "will congress #leadonclimate or pander to #climatechange deniers and #junkscience?".

Cluster 4 (12.8% of the classified tweets, label: *global warming*) contains words that specifically refer to global warming with technical terms describing the state of the environment, for example: "dyk [did you know] how big of a difference two degrees can make watch to learn more #globalwarming #saveourseaice". It should be noted that the same lexicon is also used in denying global warming, for example: "record snowfall in Montana how is that possible with #globalwarming?". Upon closer examination of the 100 tweets associated with this cluster with a higher chi-square score, approximately one-tenth of these clearly express climate change denial processes. Other tweets do not clearly express denial processes; however, they use irony to critique the FFF movement.

By examining the association of each cluster with the day of posting the relative tweets (Figure 2, top) we can see that the *protest movement* cluster, related to FFF, is most present during the specific days of FFF events. Conversely, the other clusters are only associated with the remaining days of the week. Similarly, the protest movement cluster is most prevalent during months exclusively tied to it (Figure 2, bottom), while clusters related to all other topics are associated with the remaining months in a complementary manner.

Figure 2

Over-Representation of Topics per Day and per Month



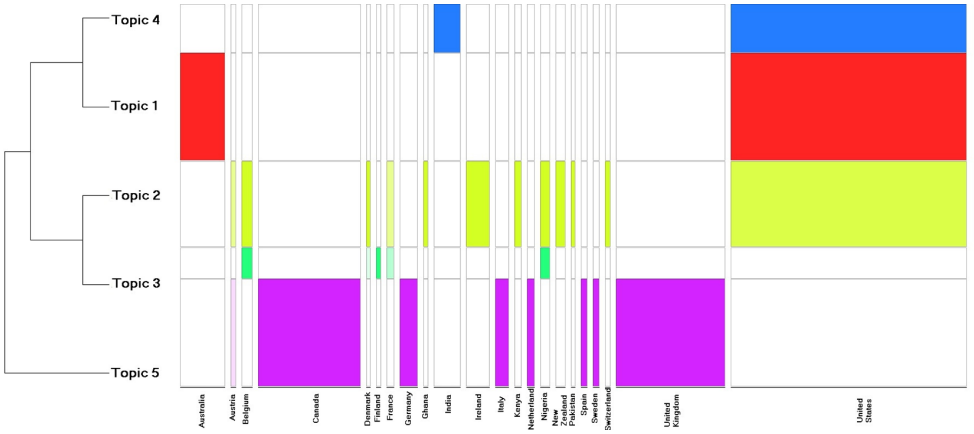
Note. The height of each class's cells is proportional to the class size in terms of the number of tweets it contains. The width of the cells is proportional to the frequency of tweets in a given day/month. The color tone is indicative of the strength of the association (chi-square index with *p*-value ranging from < .0001 to < .05) between the topic and the month (bottom) and the topic and the day (top).

Figure 3 shows the associations between clusters and the originating countries of the tweets. The USA, the country with the greatest number of tweets, is associated with the clusters *climate change*, *global warming*, and *SDGs & meeting*. The *global warming* cluster is also associated with postings from India, while *climate change* is also associated with postings from Australia. The *SDGs & meeting* cluster is associated with postings from various other countries, and, in fact, is the most shared among countries. The *sustainability* cluster is more strongly associated with postings from Nigeria, Belgium,

and Finland. Interestingly, the countries most associated with *protest movement* (Canada, Germany, Italy, Netherland, Spain, Sweden, and the UK) are exclusively associated with this cluster; Austria, which is only slightly associated with the *protest movement* cluster, is also slightly associated with *SDGs & meeting*.

Figure 3

Over-Representation of Topics per Country



Note. The height of each class's cells is proportional to the class size in terms of the number of tweets it contains. The width of the cells is proportional to the frequency of tweets in a given country. The color tone is indicative of the strength of the association (chi-square index with *p*-value ranging from < .0001 to < .05) between topic and country.

The analyses seen in Figures 1–3 examine the content of tweets in relation to climate change at times when protests related to the FFF movement were particularly salient (first research question). In the analysis shown in Table 3, we also look at the associations of structural and sociocultural characteristics of the country of tweet origin and the tweet topics (second research question). In particular, analyzing the association between the level of pollution of a country (MTCO2) and the topics of the tweets, we observed that the tweets from the most polluted countries (Quartile 4) mainly regard *climate change* and *global warming*, i.e., adaptation strategy topics. Tweets from the countries in the third quartile for pollution level are more related to *protest movements*, while those from the less polluted countries instead concern *sustainability* and *SDGs & meeting* (i.e., mitigation topics).

Table 3

Significant Association (Chi-Square Index) Among Topic and Level of the Variables

	Pollution (MTCO2) (Level of)				Power distance (Level of)				Individualism (Level of)				Uncertainty avoidance (Level of)				Long term orientation[a] (Level of)			
Topic/Variable	**L**	**ML**	**MH**	**H**	**L**	**ML**	**MH**	**H**	**L**	**ML**	**MH**	**H**	**L**	**ML**	**MH**	**H**	**L**	**ML**	**MH**	**H**
5 - Protest movement			**			**				*	**			**		**		**	**	**
3 - Sustainability		**			**			**	*	**	**				**	*				**
2 - SDG & meeting	**	**			**			**	**	**	**				**	**	**			**
1 - Climate change				**		**	**					**	**	**			**			
4 - Global warming				**			**	**	**			*	*				**			

Note. Levels: L = low; ML = medium/low; MH = medium/high; H = high. Variables: pollution, power distance, individualism, uncertainty avoidance, long term orientation.

*$p < .05$. **$p < .0001$.

[a]One considered country (Kenya) has no score on this variable.

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Together with structural factors, we monitored for differences in the tweeted topics based on sociocultural factors associated with each country (power distance; individualism; uncertainty avoidance; long-term orientation). The association among clusters and degree of power distance (Table 3) indicates that tweets from the countries with the lowest score on this sociocultural variable are more about *sustainability* and *SDGs & meeting* (i.e., mitigation topics), whereas those from countries with the highest score on are also about *global warming* (i.e., mitigation and adaptation topics). Tweets from countries falling in the third quartile (the majority of tweets) mainly concern topics regarding adaptation strategies (*climate change* and *global warming*), while tweets from countries falling in the second quartile regard mostly *protest movement* and *climate change* topics.

Tweets from the most individualist countries concern mostly the politically connoted *climate change* topic and slightly less so *global warming* (Table 3). Although tweets from less individualist countries again concern *global warming*, there is also a greater tendency to concern mitigation topics. Tweets from countries with a middle score for individualism instead concern mainly the *protest movement* topic.

As regards uncertainty avoidance (Table 3), tweets from the countries with the lowest score (i.e., least discomfort with future uncertainty and ambiguity) concern more adaptation topics. Tweets from countries in the second quartile tend more to concern *climate change* and *protest movement* topics. Tweets from countries with a medium-high score in uncertainty avoidance pertain more to mitigation topics and those from countries in the fourth quartile (highest score) also *protest movement*.

Lastly, tweets from countries with a short-term orientation tend to concern adaptation topics and *sustainability* (Table 3). The tweets from the rest of the countries (Quartiles 2, 3, 4) result as most concerned with the *protest movement* topic, and those from countries with the highest score in long-term orientation also concern mitigation topics.

Discussion

This paper uses natural data (tweets) for the investigation of social representations of climate change over a period of time when the FFF movement brought the climate crisis to the fore in worldwide media. It investigates the main themes and social anchoring of representations of climate change at the country level, i.e., in relation to the structural and sociocultural factors of the countries in which people who produced the tweets declare they live.

Our first research question addresses the themes related to climate change that were shared on Twitter (now X) during the peak of FFF activity, encompassing the overall content of representations. From our results, the majority of shared content on climate change concerns rhetoric on calls to action and more specifically the FFF movement. Our

results, although employing a different methodology from Suitner et al. (2023), align with their conclusions, suggesting that the FFF movement appears to be able to drive attention toward climate change issues, particularly when the movement organizes and mobilizes followers in off-line collective actions. Indeed, we found that messages related to the *protest movement* topic appear related to the months and days when collective actions were organized and implemented.

As for the remaining emerging themes, a distinction is apparent: two of the topics refer to efforts to reduce or prevent global warming (Clusters 2 and 3), while the other two (1 and 4) encompass strategies related to adjusting or reacting to the impacts of climate change. It is noteworthy that some of the reactions in Topic 4 include denial processes, which can therefore be interpreted as forms of dysfunctional coping (Joffé, 1999).

The *protest movement* topic appears to be disconnected from all the other topics. In other words, the more the protest movement topic dominated the representation of climate change, the lower the presence of other topics. What we observe, therefore, seems to be a case of the effective use of social media in coordinating a worldwide movement. However, when the focus is on organizational issues, other topics remain in the background.

Our data also show that, in general, the contents conveyed with respect to climate change are coherent with respect to that already observed in previous studies (e.g., Fischer et al., 2012; Jaspal et al., 2014). With the exception of the topic related to the call for action of the FFF movement, representations of climate change reflect hegemonic representations within the public debate. For example, tweets discuss issues related to the climate, where the debate sometimes revolves around whether the climate is actually changing or not (indicating the presence of denial processes). This is accompanied by images (illustrative of the objectification process) depicting glaciers melting and the presence or absence of snow (cf. Topic 4). Other tweets contain discourses covering energy-related concerns, addressing emissions associated with housing and transportation, as well as the transition to renewable energy sources (cf. Topic 3), along with political interventions (cf. Topic 3) advocating for emission reduction and energy transition. No theme emerges (we cannot determine whether it is because they are not present or because they remain too marginal to be grasped) in contrast to the hegemonic representation of climate change, such as topics like degrowth and anti-capitalism. A different type of analysis or data, not reliant, for example, on social media, could shed light on the FFF movement's capacity to contribute to generating emancipated or even polemical representations.

To address the second research question, we investigated whether the identified themes vary among countries and how they are rooted in structural and sociocultural factors associated with different contexts. Our results on the content of tweets in relation to the countries' structural factor (level of pollution) as an anchoring variable, show

that the tweets from countries with a medium-high pollution level are more focused on protest movements, while those from less polluted countries are significantly related to mitigation topics (sustainability and SDGs & meeting). Instead, tweets from the most polluted countries (Quartile 4) are mainly focused on climate change and global warming, i.e., adaptation topics. A greater focus on the problem—of course with all the due differences between climate change and global warming—can be counterproductive in terms of the ability to imagine alternative futures, as well as political and concrete means of counteracting climate change (cf. Rizzoli et al., 2017). The presence of denial processes within tweets from the most polluted countries further aligns the results with the literature, suggesting that increased proximity to climate change issues may lead individuals to distance themselves from the problem, employing denial processes as a dysfunctional coping mechanism (Joffé, 1999). However, within the global warming cluster, only some of the tweets clearly exhibit this process. Therefore, more specific analyses would be necessary to further and in-depth reason on the implication of denial processes presence (cf. Rizzoli, 2024). Furthermore, consistent with the literature (cf. Dany et al., 2014), we observe that tweets from the most polluted countries (i.e., closer to the object) convey descriptive characteristics associated with the social object (e.g., words like snow, weather, temperature used for describe the situation), while those from less polluted countries (i.e., more distant from the object) emphasize normative components (e.g., c.f. the references to the policies in Topic 2 and 3).

Regarding anchoring to sociocultural variables, from the current results, it is difficult to detect clear trends concerning power distance. Tweets from countries that are low in levels of power distance refer mainly to mitigation topics, but those from countries with a high power distance also mention those topics. Most of the tweets, however, originate from countries ranking in the middle levels, and in line with the expectations derived from the description of the sociocultural characteristic, those positioned at a medium-low level tweet more about protest, while those who are positioned at a medium-high level tweet more about adaptation topics.

Results on individualism remain generally (although not markedly) in line with the literature, which describes an individualist orientation as less likely to prevent climate change (e.g., Xiang et al., 2019): in our case, tweets from the most individualistic countries are associated with adaptation topics.

Regarding uncertainty avoidance, we observed that tweets from countries characterized by lower levels of uncertainty avoidance are mainly associated with adaptation topics; on the contrary, tweets from countries with the highest scores in uncertainty avoidance are associated with the protest movement and mitigation topics. This result may appear to contradict the literature, which usually associates a high degree of uncertainty avoidance with resistance to change (Slawinski et al., 2017). However, if we interpret mitigation strategies as preventive (aimed at controlling a bleak future), it is logical to assume that high scores in uncertainty avoidance are linked to mitigation, as

"acting now to prevent" provides a sense of control over the future. Conversely, if we interpret adaptation strategies as a posteriori response, which can result in dysfunctional symbolic coping (i.e., denial), it makes sense that low scores in uncertainty avoidance are associated with the thought of eventually worrying about a problem if and when it presents itself. However, this reasoning requires further in-depth analysis and inferential studies.

Regarding long/short-term orientations, we noticed that tweets from countries that rank more highly in short-term orientations concern more adaptation topics, while those from countries with a long-term orientation are related to protest movements and mitigation topics. This confirms the results from previous studies using other methods. In cultural contexts oriented to the short term, the focus on the here and now seems to lead to talk of adaptation in terms of responses to current problems, where these strategies may also present themselves as (dysfunctional) coping mechanisms. Focusing on problems (or denying them) rather than on change would hinder the ability to project alternative visions of the community over time (Bauer & Gaskell, 1999). The positive links between future orientation, the FFF protest movement, and finally mitigation topics, are instead coherent with previously observed relationships between future orientation and sustainable behaviors (Corral-Verdugo & Pinheiro, 2006; Slawinski et al., 2017).

Limitations

Although the current paper has some limitations, these can be taken into account in suggesting future research. First, the research considers only the period characterized by the emergence of the FFF movement, while it would be interesting to also observe longitudinal data, comparing times when the movement was organizing protests and when it was not. In this case, one of the challenges would then be to collect sufficient natural data from the different countries across discrete time periods, that is, what the attention brought to climate change by the FFF movement made possible. From a methodological point of view, the choice of associating geolocation with the tweet is only an approximation, since it is not certain that the person tweeting actually has that nationality. Nor are we able to identify anything of individual orientations, however, this remains an issue inherent in the type of data and not in conducting the research itself. In addition, we considered English-only tweets, since lexicometric analyses require linguistic homogeneity, ruling out a multilingual corpus. Because of this, the majority of tweets considered will be mostly from English-speaking countries, potentially leading to the omission of local discourses. Future, more comprehensive research could incorporate these local perspectives, taking into account the challenges associated with analyzing a multilingual corpus. Additionally, it is important to note that certain countries may be underrepresented due to language barriers, which may result in a results discussion based on a limited number of tweets. Moreover, although we had a valid reason for choosing this social media platform as a source of data, we acknowledge that Twitter (X)

has a particular user base, typically more educated and of higher income (Blank, 2017), which does not invalidate reasoning but does not make it possible to generalize them to the entire population.

Conclusions

Summing up, the current study provides insights into the roles of specific country-level anchors in the representations of climate change. The FFF movement has had great merit in stimulating debate on the relative issues (which still receive a relatively low level of attention compared to the significant risks they pose) in the public arena. It therefore remains important to understand how to contribute to the ongoing debate, becoming promoters of change. Studying the representation of climate change and how it varies cross-country can help to better understand a phenomenon from a societal perspective, informing policy and facilitating international dialogs. From the current study, we can see that social media present both possibilities in the construction of social representations: they have the potential to trigger social change, but at the same time can perpetuate pre-existing representations that can foster inaction. Thanks to this kind of research, we are able to more usefully understand the interactions of the different country-level anchors with these two opposing tendencies. It is important to note that in the present study contents of topics falling under the label of "mitigation" are more oriented toward the need for changes in habits to reduce the effects of global warming, while those falling under the label of "adaptation" are more focused on addressing problems, sometimes through denial as a strategy of dysfunctional coping. Only in these terms can the present results be meaningfully interpreted. In broader conceptions, it is useful to integrate both mitigation and adaptation strategies for addressing climate change. However, it is important to understand how these strategies are discussed in everyday discourse within their respective contexts for a deeper understanding of a socially relevant phenomenon that requires action.

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Ethics Statement: This article does not contain any studies involving human participants performed by any of the authors. The manuscript adheres to ethical guidelines specified in the APA Code of Conduct and our national ethics guidelines.

Data Availability: The data that support the findings of this study, their description and codebook are available (see Rizzoli et al., 2024).

Supplementary Materials

For this article, the following Supplementary Materials are available(see Rizzoli et al., 2024):

- Data information and codebook to reproduce the analyses
- Corpus (19,112 English language tweets)
- Files required to reproduce the data pre-processing
- Files needed to reproduce topic detection and the R script to represent the association between variable mode and class

Index of Supplementary Materials

Rizzoli, V., Salvador Casara, B. G., & Sarrica, M. (2024). *Supplementary materials to "Tweeting about a revolution? A cross-national analysis of tweets on climate change during the rise of "Fridays for Future""* [Data, codebook, code]. PsychOpen GOLD. https://doi.org/10.23668/psycharchives.15428

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Appendix

Table A1

Distribution of Countries in Terms of Quartiles Within the Variables Considered

Country	MTCO2	MTCO2Q	Power distance	PD	Individualism	I	Uncertainty avoidance	UA	Long term orientation	LTO
Australia	420,2209	4	38	2	90	4	51	2	21	1
Austria	68,8699	2	11	1	55	2	70	4	60	3
Belgium	99,6652	2	65	4	75	3	94	4	82	4
Canada	568,4122	4	39	3	80	4	48	2	36	2
Denmark	34,8097	1	18	1	74	3	23	1	35	2
Finland	46,9891	2	33	1	63	2	59	3	38	2
France	337,9134	3	68	4	71	3	86	4	63	4
Germany	759,0019	4	35	2	67	2	65	3	83	4
Ghana	18,2984	1	80	4	15	1	65	3	4	1
India	2654,101	4	77	4	48	1	40	1	51	3
Ireland	38,9311	1	28	1	70	2	35	1	24	1
Italy	338,0267	3	50	3	76	3	75	4	61	3
Kenya	18,4862	1	70	4	25	1	50	2	ND	ND
New Zealand	34,7658	1	22	1	79	4	49	2	33	1
Nigeria	127,2942	2	80	4	30	1	55	3	13	1
Pakistan	223,5404	3	55	3	14	1	70	4	50	2
Spain	268,2338	3	57	3	51	1	86	4	48	2
Sweden	41,0269	2	31	1	71	3	29	1	53	3
Switzerland	36,8734	1	34	2	68	2	58	3	74	4
Netherlands	161,624	3	38	2	80	4	53	2	67	4
UK	379,0399	4	35	2	89	4	35	1	51	3
US	5416,278	4	40	3	91	4	46	1	26	1

Note. MTCO2 = metric tons of carbon dioxide equivalent.; MTCO2Q = metric tons of carbon dioxide equivalent (Quartile); PD = Power distance (Quartile); I: Individualism (Quartile); UA = Uncertainty avoidance (Quartile); LTO = Long term orientation (Quartile).