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Introduction

Distrust in science is well known to be a key driver of climate scepticism.¹⁻⁵ People who hold views that lie outside the scientific consensus are more likely than others to disbelieve that global warming is happening, is caused by anthropogenic activity or is having (or will have) adverse effects.^{6,7} As a result, they are less willing to adopt lifestyle changes⁸ or support policies consistent with climate mitigation.^{6,9} Policymakers are often dissuaded from progressing climate mitigation due to the potential backlash from vested interests or sceptical segments,^{6,10} particularly in highly polarised contexts.

Similar concerns arise for the other major challenge of the 2020s – the COVID-19 pandemic.¹¹ Compared to people who trust science, science sceptics are more likely to believe that COVID-19 poses a smaller threat¹² or originates from a different source (such as 5G technology or purposeful manufacture)¹³ than that advanced by mainstream science. Attitudes towards science influences individual behaviours critical for reducing the spread of the virus such as social-distancing, compliance with self-isolation or stay-at-home mandates¹⁴ and vaccine hesitancy.^{15,16} As with climate change, such sceptical attitudes could deter governments from adopting the most effective mitigative measures for combatting the pandemic if they are viewed as politically costly.^{13,17,18}

Social scientists have identified several reasons why people might hold sceptical attitudes towards controversial scientific issues. The deficit model, for example, asserts that scepticism stems from a lack of accurate information.¹⁹ The prevalence of misinformation about climate change and COVID-19 might be seen as explaining science scepticism on both issues.^{12,20-22} However, previous research shows that information alone has had limited ability to change sceptical attitudes towards climate change²³ and vaccines in the past,²⁴ suggesting it is unlikely to be the main source of scepticism.^{13,16}

A better-supported explanation appears to be that scepticism emanates from a psychological motivation that causes people to reject science that challenges pre-existing ideological beliefs.²⁵ For

example, past studies show political conservatives are more likely than liberals to be sceptics on climate change and COVID-19 because the scientific consensus suggests remedies that are difficult to reconcile with conservative ideological foundations such as an aversion to government involvement.^{13,16,26} Another thesis is that science scepticism stems from perceptions regarding the credibility of the source.⁴ For example, believers in conspiracy theories are predisposed to distrust elites and institutions (e.g., politicians, corporations and scientists) and, therefore, doubt their claims about scientific issues such as climate change^{3,27,28} and, more recently, the pandemic.^{16–18} In particular, such studies consistently find that distrust in scientists is strongly correlated with scepticism towards climate change^{1,5,28–30} and COVID-19.^{11,30,31} The association holds irrespective of access to accurate information, ideological orientation and belief in conspiracy theories⁴ and has even been found to moderate the effect of other drivers of climate beliefs such as news media.³²

The prevalence of climate sceptics and antivaxxers

We investigate the influence of trust in scientists on sceptical attitudes towards climate change and COVID-19 vaccination among the public. Our analysis employs novel data obtained by administering nationally representative surveys (see Methods and Supplementary Methods) in eight key countries for global climate and COVID-19 mitigation (Australia, Brazil, China, India, Japan, South Africa, UK and US). Existing research on the relationship between trust in scientists and climate scepticism^{1,3,36,37} and vaccine hesitancy^{1,38} focuses mainly on polarised national contexts but largely omits other countries that are increasingly important for international responses to both challenges. Using large representative national surveys (n=2000), we (separately) asked respondents about their views towards a core aspect of climate scepticism (how big a threat climate change is for their country) and antivaxxism (how likely they are to take a COVID-19 vaccine if offered one). We also asked respondents how much priority should be given to the economy vis-à-vis combatting climate change or COVID-19, which was correlated (to varying degrees across countries) with sceptical attitudes towards climate change and COVID-19 vaccination respectively. We distinguish between respondents who are sceptics on both climate change and COVID-19 vaccination (persistent or double sceptics), climate sceptics who are not antivaxxers, and antivaxxers who are not climate sceptics.

While most respondents accepted the scientific consensus on climate change and COVID-19 vaccination, many respondents exhibited at least some degree of scepticism: 35% did not consider climate change a major threat to their country and 17% were unlikely to take a COVID-19 vaccine if offered one. Only a small minority (6%) of respondents selected the most sceptical response towards both issues, i.e., that climate change does not pose any threat to their country *and* that they would definitely not take a COVID-19 vaccine.

Those completely dismissive of the threat of climate change amounted to less than 5% in 6 of the 8 countries tested, but that figure was notably higher in Australia (9%) and the US (14%) where climate science is more polarised compared to other countries ($P < 0.01$) (figure 1A). Only a small minority (~2%) of respondents indicated that they would definitely not take a COVID-19 vaccine in 6 of the 8 countries, whereas in South Africa and the US, those exhibiting the strongest antivaccine position were significantly higher ($P < 0.001$), amounting to 20% and 10% respectively (figure 1B).

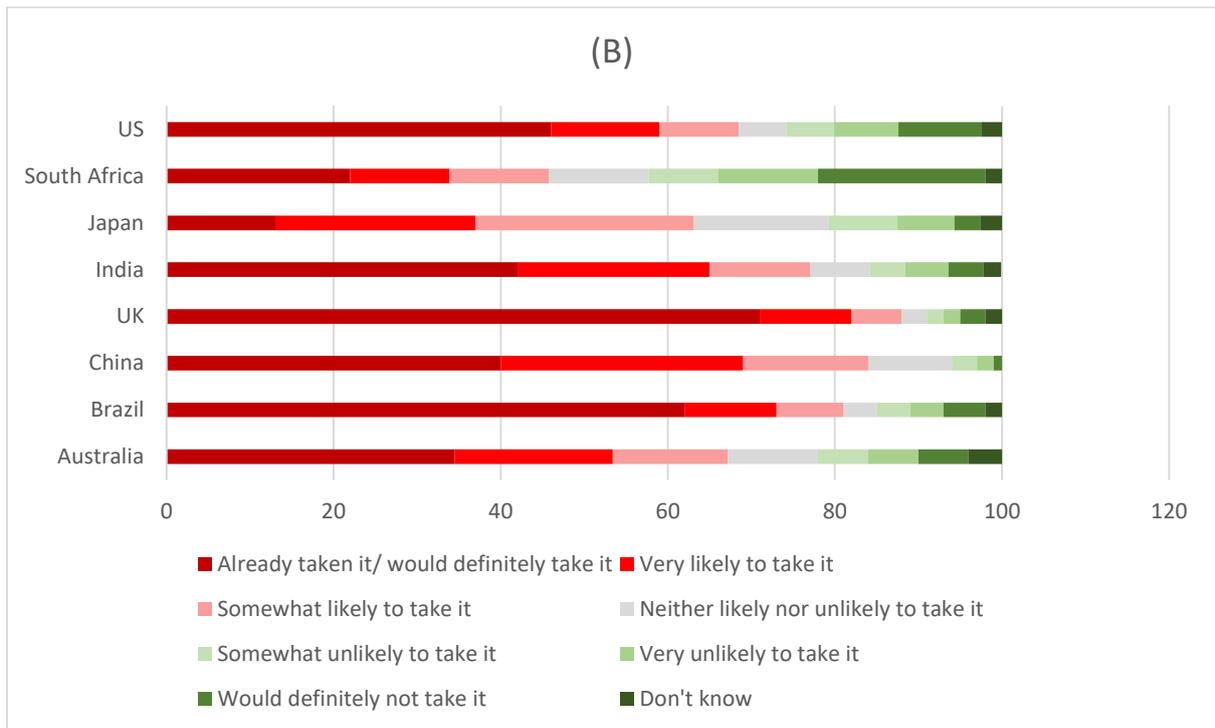
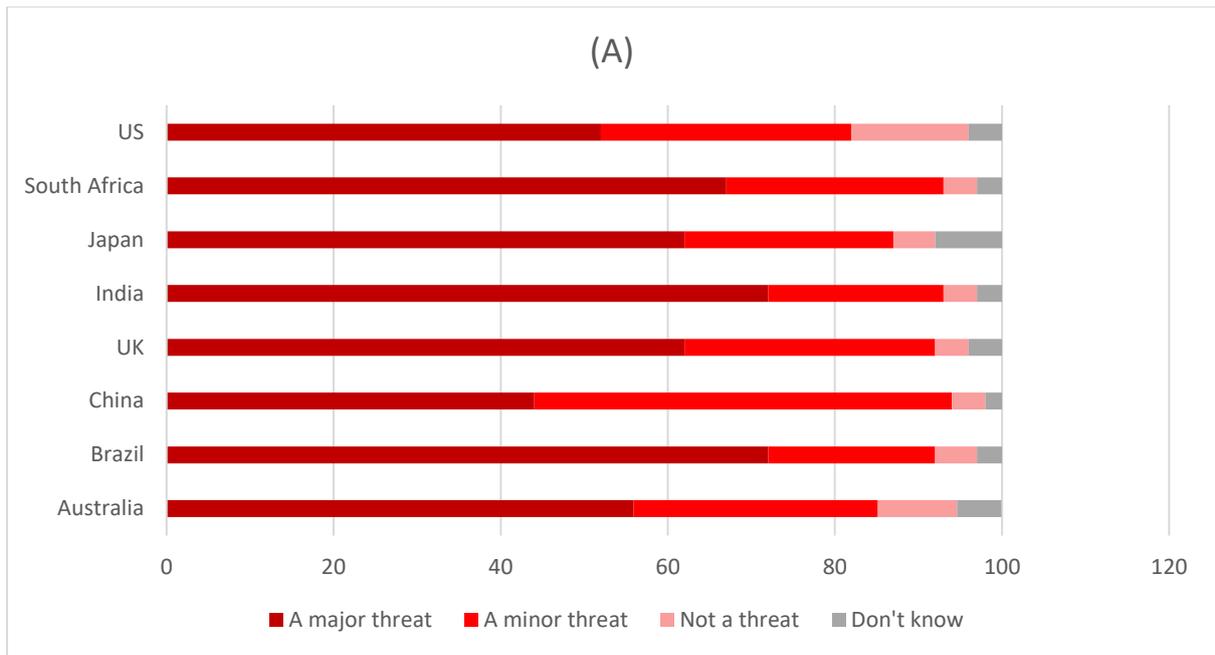


Figure 1: Prevalence of attitudes towards (A) climate change and (B) COVID-19 vaccination across countries.

We also explored assessments of how much importance should be given to the economy over (separately) protecting the public from climate change and COVID-19. These attitudes were positively correlated with our dependent variables; pooled correlations were 0.24 for economic attitudes and climate sceptics and 0.20 for economic attitudes and antivaxxers (both $P < 0.001$). Correlations were generally stronger in advanced economies and weaker in developing countries. All correlations were significant at $P < 0.001$ for all countries except for antivaxxers in China (Supplementary Table S1).

Distrust in scientists as a key driver

There are several reasons why distrust in scientists might drive scepticism on climate change and COVID-19 vaccination. Most obviously, the complex, technical nature of both issues renders them less accessible to laypeople – trust in scientific experts becomes a cognitive shortcut for accepting mainstream understandings largely premised on scientific consensus.^{31,32,33} Second, effective mitigation of both issues imposes significant societal costs, including radical behavioural changes such as modifying lifestyles to reduce carbon footprints and compliance with social-distancing and lockdowns to prevent the spread of the virus, which are associated with feelings of powerlessness, creating additional impetus for questioning the scientists who inform or even champion these intrusive policy responses.^{13,17}

We use logistic regression to evaluate the extent to which, if at all, climate sceptics and antivaxxers are driven by distrust in science. The dependent variables are dichotomised, such that 1 indicates the individual is a climate sceptic (believes that climate change poses no threat to their country) or antivaxxer (would definitely not take a COVID-19 vaccine if offered one) and 0 otherwise (see Methods). Respondents who chose ‘don’t know’ options were excluded from the analysis because they could not be assigned to a sceptic or non-sceptic position. Several controls were included to isolate the effect of trust in scientists from other correlates of sceptical attitudes identified in the literature – namely: age, gender, education, prioritising environment/ health, objective climate knowledge, self-declared energy knowledge, self-declared economic hardship, responsibility attribution for resolving climate change/ the COVID-19 pandemic and precautionism. Respondents were asked to rate their trust in university scientists for providing accurate information on sustainable energy and environmental issues on a seven-point Likert scale, which was used to define a trust variable ranging from 1 (do not trust at all) to 7 (trust completely). Supplementary Table S2 shows the coding strategy for all variables and Tables S3-S10 descriptive statistics for each country.

The predicted marginal effects of our main drivers are shown in Tables 1-2 (for relative odds estimates see Supplementary Tables S11-S12). We employ separate regressions to evaluate the drivers behind three combinations of sceptical positions – (i) both climate sceptic and antivaxxer; (ii) climate sceptic but not antivaxxer; and (iii) antivaxxer but not climate sceptic – allowing us to partition our analysis to examine the role of distrust in science (and other factors) in sustaining these different sceptical attitudes. Table 1 shows whether the probability that respondents are climate sceptics or antivaxxers (or both) is influenced by the explanatory variables. Respondents who distrust scientists are significantly more likely to be both climate sceptics and antivaxxers compared to those who trust scientists ($P < 0.001$). They are also significantly more likely to feel that climate change does not pose a threat to their own country without being antivaxxers ($P < 0.001$) or feel strongly about not taking a COVID-19 vaccine without being climate sceptics ($P < 0.001$). Differences in the trust estimates across the models reveal important nuances in the role of trust in driving the different combinations of sceptical attitudes towards climate change and COVID-19: The (absolute) trust estimate in the double-sceptic regression (Model 1A) is approximately a seventh of the size of the estimates in the single climate sceptic (Model 2A) and antivaxxer (Model 3A) regressions, suggesting that it is a much weaker driver of sceptical attitudes among respondents who are sceptics on both issues compared to those who are only sceptics towards either climate change or COVID-19 vaccination.

Parameter	Model		
	1A	2A	3A
	Climate sceptic and antivaxxer	Climate sceptic only	Antivaxxer only
Age	9.34E-6	4.42E-4***	-1.34E-4T
Female	-6.15E-4	-0.02***	0.01*
Degree	-1.84E-3*	-2.34E-3	-0.01***
Prioritise environment	-4.45E-3***	-0.04***	-4.71E-3
Prioritise health	-3.00E-3***	-0.01***	-0.01**
Objective knowledge	-6.80E-5	-4.11E-3***	-3.88E-4
Self-declared energy knowledge	3.84E-4T	3.14E-3**	3.06E-4
Trust in scientists	-1.52E-3***	-0.01***	-0.01***
Perceived income sufficiency	1.18E-4	-9.21E-4	0.01***
Climate responsibility	-1.96E-5	-2.94E-3***	1.14E-3*
COVID-19 responsibility	-4.65E-4***	9.13E-3*	-2.71E-4
Precautionism	1.27E-4	-1.48E-3***	1.15E-3**
N	203	796	816
R2	0.27	0.16	0.14

Table 1: Probability of being a climate sceptic, antivaxxer or both (N=14956).

Note: The dependent variable is binary, taking the value of 1 if an individual response is categorized as the defined sceptic attitude towards climate change and COVID-19 and 0 otherwise. Model (1A) estimates the probability of an individual being both climate sceptic and antivaxxer, model (2A) climate sceptic but not antivaxxer and model (3A) antivaxxer but not climate sceptic. Country controls are included but not reported. Individual country regressions are reported in Table 3. *P<0.05, **P<0.01 and ***P<0.001.

Table 2 shows that respondents who give complete precedence to the economy whether only relative to climate or COVID-19 mitigation or both climate change and COVID-19 are significantly more likely to distrust scientists (P<0.001). While less striking than Table 1, the difference in the (absolute) magnitude of the trust estimates across the models indicate that distrust in scientists has a more determinative effect for respondents whose prioritisations are consistent with single sceptics (Models 2B & 3B) versus prioritisations consistent with double sceptics (Model 1B).

Parameter	Model		
	1B	2B	3B
	Prioritise economy over both climate and COVID-19	Prioritise economy over climate only	Prioritise economy over COVID-19 only
Age	7.33E-5*	4.77E-4***	1.12E-5
Female	-2.91E-4	-2.61E-3	-5.34E-4
Degree	1.18E-3	-0.01**	-3.52E-3T
Prioritise environment	-0.01***	-0.03***	-2.43E-3
Prioritise health	-0.01***	-0.01**	-0.01***
Objective knowledge	-1.50E-3***	-0.01***	3.71E-4
Self-declared energy knowledge	0.01***	0.01***	2.10E-3**
Trust in scientists	-2.14E-3***	-3.91E-3***	-2.31E-3***
Economic hardship	3.88E-4	-3.90E-3**	1.69E-3*
Climate responsibility	-1.19E-3***	-2.69E-4	-2.50E-4
COVID-19 responsibility	-1.80E-3***	9.56E-4T	-2.01E-3***
Precautionism	2.29E-3***	4.22E-3***	1.29E-3***
N	469	867	388
R2	0.23	0.08	0.10

Table 2: Probability of giving complete priority to the economy over climate protection or combatting COVID-19 or both (N=14956).

Note: The dependent variable is binary, taking the value of 1 if an individual response is categorized as the defined sceptic attitude towards climate change and COVID-19 and 0 otherwise. Model (1B) estimates the probability of an individual giving complete priority to the economy over combatting climate change and the pandemic, model (2B) the probability of giving complete priority to the economy over climate protection but not combatting COVID-19 and model (3B) the probability of giving complete priority to the economy over combatting COVID-19 but not climate protection. Country controls are included but not reported. Individual country regressions are reported in Table 4. *P<0.05, **P<0.01 and ***P<0.001.

Figure 2 shows the probability of being a double sceptic, climate sceptic or antivaxxer and holding comparable prioritisations of the economy relative to climate or COVID-19 depending on respondents' trust in university scientists. Across the range of trust levels, distrust in scientists is consistently a stronger predictor of whether one is a single-issue rather than double sceptic: The difference is strongest for people who completely distrust scientists, who are approximately four times more likely to be antivaxxers and five times more likely to be climate sceptics than double-sceptics. Similarly, complete distrust in scientists makes one twice as likely to give complete priority to the economy over climate change than prioritise the economy over both climate and COVID-19. However, as shown by the overlapping blue and grey confidence intervals, the distinction is less determinative for double economy prioritisers and people who prioritise the economy over COVID-19 only. This could point to a limitation in our dependent variable rather than the relative unimportance of scientific trust for economy-over-COVID-19 prioritisers as preventative measures against the pandemic have resulted in more immediate economic effects compared to climate mitigation, which may have affected the priority that people give to economy relative to COVID-19. Collectively, these results provide consistent evidence that distrust in scientists is a primary driver for people who are either climate sceptics or antivaxxers, while being less important for double sceptics. Our main results also hold when we replace the dependent variable with making lifestyle changes to address climate change, suggesting that distrust in scientists might inhibit behavioural

change compatible with climate mitigation amongst single-sceptics, while having significantly ($P < 0.0001$) weaker effects on double-sceptics (see Supplementary Table S13). The relationship between lifestyle changes due to the COVID-19 and trust in scientists is notably weaker (though still significant at $P < 0.0001$) – a likely reflection of the involuntary nature of COVID-19-related lifestyle choices rather than the diminished role of trust in scientists.

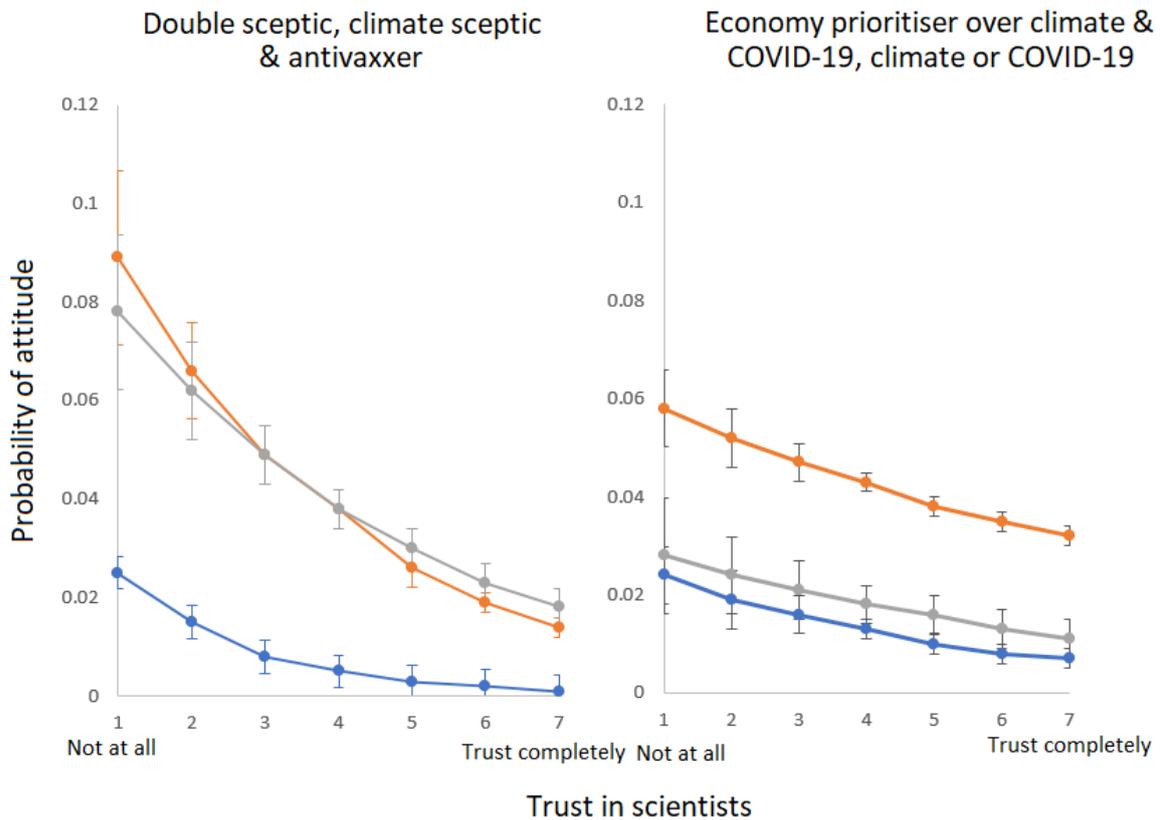


Figure 2: Predicted probability of being a double sceptic, climate sceptic or antivaxxer or giving complete precedence to the economy over climate change and COVID-19, climate change or COVID-19 depending on trust in university scientists.

The probability of holding a sceptical position or completely prioritizing the economy predicted by the logistic regression models shown in Tables 1-2. The blue lines show the difference in the predicted probability of being a double sceptic or giving complete priority to the economy over climate and COVID-19, orange lines climate sceptic or giving complete priority to the economy over climate and grey lines antivaxxer or giving complete priority to the economy over COVID-19 for respondents who have different levels of trust in university scientists. The vertical lines show the 95% confidence intervals.

Previous research suggests that people who are both climate sceptics and antivaxxers tend to hold a more intense range of attitudes such as, for example, (far-right) conservative ideological orientation^{11,13,17,26} and general (strong) distrust of elite institutions, which are typically associated with people who are sceptics towards a broader range of issues.²⁶⁻²⁸ This profile creates a strong psychological motivation to reject scientific consensus as a way of reinforcing the underlying worldviews, ideologies and fears that comprise the sceptic mindset.^{11,32} Therefore, a possible reason for the relatively stronger influence of distrust in scientists among single versus double sceptics is that the latter are motivated by a psychological need to reject scientific consensus as a way of reinforcing the

underlying worldviews, ideologies and fears that comprise the sceptic mindset^{11,32} whereas single-issue sceptics, who do not possess such psychological bias against elite institutions, are influenced by a more isolated distrust in scientific consensus on climate change or COVID-19 vaccination. Figure 3 shows the pooled differences between some of the core sceptical attitudes among double-sceptics, single-sceptics (sceptics on either climate change or COVID-19 vaccination) and non-sceptics. While respondents who fall under any of the three sceptic combinations are generally more right-leaning and distrusting of social institutions compared to non-sceptic respondents, people who are both climate sceptics and antivaxxers tend to situate themselves further right-of-centre and exhibit higher levels of distrust towards scientists, their national government and television news compared to single-sceptics. Differences in political orientation and distrust in social institutions are consistently significant ($P < 0.001$) between double and single sceptics, and between non-sceptics and (double and single) sceptics (Supplementary Tables S14-S15). The equivalent figures for the separate country samples in Supplementary Figure S2 show that these patterns are true for three of the four advanced economies in our dataset (Australia, the UK, and US), while distrust in scientists, government, and television news (but not rightward orientation) is higher among double sceptics than single sceptics in India and Japan. When considered alongside our previous results in Tables 1-2, which showed that a broader range of factors such as (self-declared) energy knowledge, perceived economic hardship and precautionism are separately associated with climate sceptics and antivaxxers but not double-sceptics, these correlations suggest that single-issue sceptics (i.e., climate scepticism without antivaxxism and antivaxxism without climate scepticism) are motivated by a different range of factors to double sceptics.

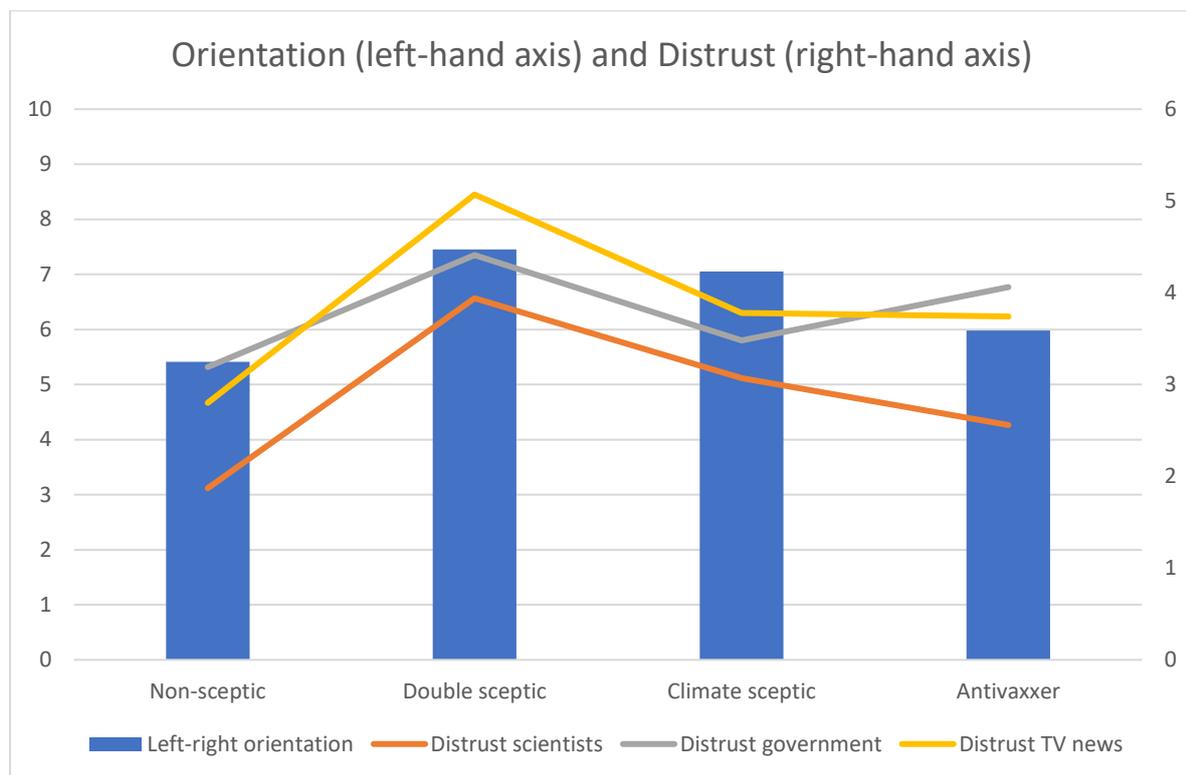


Figure 3: Pooled mean values of four key variables across non-sceptic, double sceptic and single sceptic segments. The blue bars show the mean score respondents assigned when asked to locate themselves on a left-right political scale from 0 (left) to 10 (right). Orange lines show mean levels of respondents' distrust in university scientists, grey lines their national government and yellow lines television news from 0 (completely trust) to 6 (do not trust at all). Chinese respondents were not asked questions on left-right orientation and distrust in national government.

Figure 4 shows the predicted probability of being a double sceptic, climate sceptic or antivaxxer across the range of trust levels separately for each country (see Supplementary Table S18 for full results). For most countries (Australia, Brazil, UK, Japan and US), the predicted probability of being a double sceptic is consistently lower than the probability of being a climate sceptic or antivaxxer across the range of trust in scientist levels, suggesting that distrust in scientists is more determinative for people who are single, rather than double, sceptics. In China and India, however, the probability of being a double sceptic (and antivaxxer separately in China) appear autonomous from trust in scientists, although we acknowledge that these anomalies might reflect limitations in our research methodology such as the exclusion of rural respondents in India and sensitive political environment in China as much as the divergent influence of trust in scientists. While the predicted probabilities of being a double or single sceptic in South Africa do exhibit the typical inverse relationship with trust in scientists, at very low levels of trust in scientists (one to two points out of seven), the probability of being a double sceptic exceeds the probability of being a climate sceptic, suggesting that in this country, climate scepticism might stem from a broader distrust of elite institutions rather than scientists.

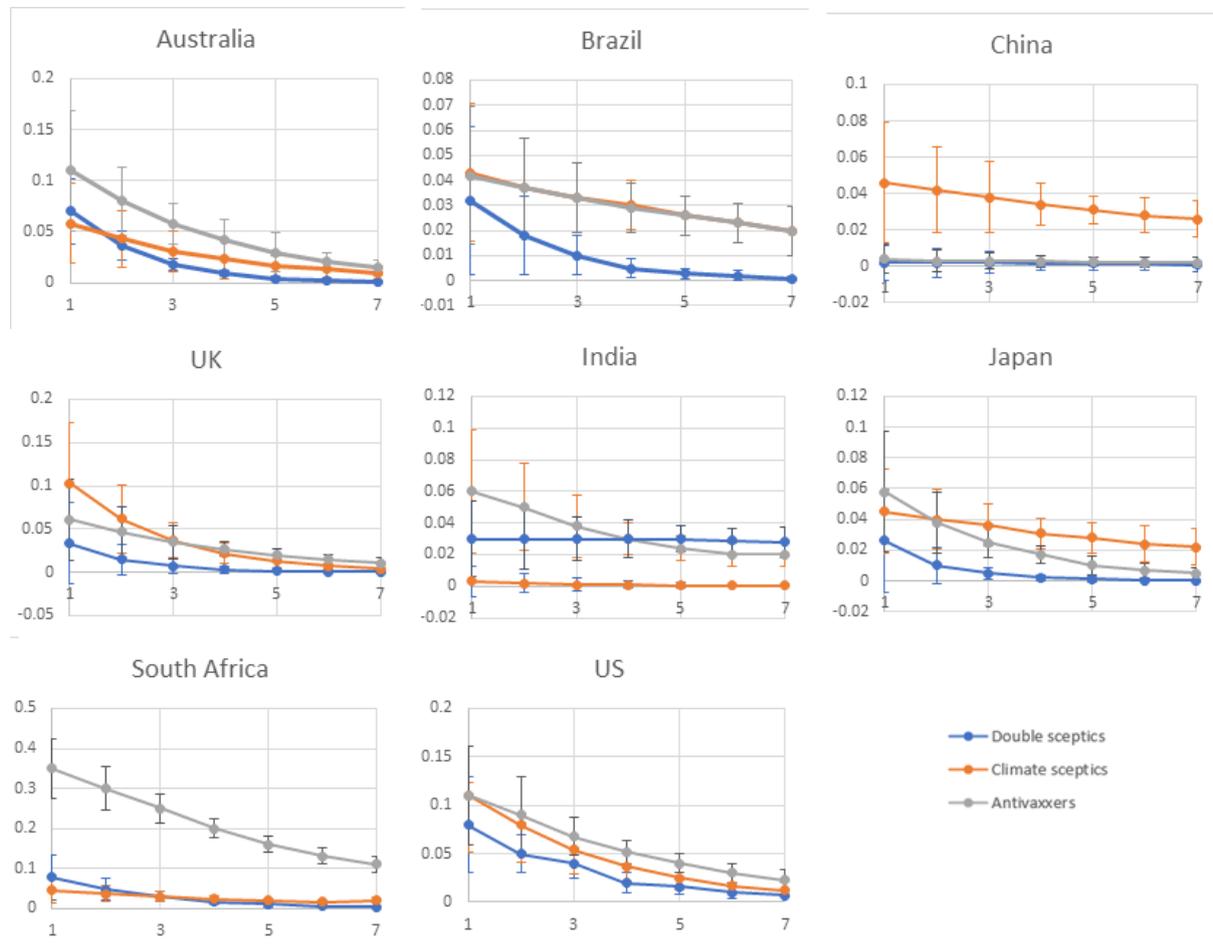


Figure 4: Predicted probability of being a double sceptic, climate sceptic or antivaxxer depending on trust in university scientists in separate country models. The probability of holding a sceptical position are predicted by the logistic regression models shown in Supplementary Table S18. Blue lines show the difference in the predicted probability of being a double sceptic, orange lines climate sceptic and grey lines antivaxxer for respondents who have different levels of trust in university scientists. The vertical lines show the 95% confidence intervals.

Limitations and conclusions

Our data facilitate comparisons across eight countries critical for global climate and COVID-19 mitigation. However, geographical diversity does create challenges. For example, it was not possible to gather data on all factors shown to influence scepticism towards climate change and vaccination in previous research. In particular, political sensitivities did not allow asking about ideological orientation in China³⁹ while the well-known difficulty of eliciting accurate disclosure of income from survey responses⁴⁰ led to these variables being excluded from our analysis. We also acknowledge that causality might flow in the opposite direction whereby scepticism on climate change and COVID-19 vaccination increase distrust in scientists or, as others have previously suggested, scepticism on climate change²⁶ (and vaccines) and trust in scientists interactively influence each other. Moreover, since climate sceptics and antivaxxers only comprise a small share of national populations, attempts to elucidate the drivers behind hard-core sceptics drawing on large-N samples are ultimately based on a relatively small number of respondents. Yet even within this select group, we find significant diversity in socio-demographic characteristics, political orientation, and levels of climate knowledge. Although this suggests scepticism may be attributable to several different drivers, it also implies that attempts to dispel scepticism will need fine-tuning to target different sceptic profiles (and sources). Nyhan et al.'s work on the 'backfire effect', for example, suggests that corrective scientific communication would reduce misperceptions for most science sceptics, but reinforce them for those whose scepticism is motivated by a need to defend their underlying (sceptic) worldviews.⁴¹ For the latter, technique rebuttal - encouraging sceptics to build trust in science by engaging in respective exchanges about scientific perceptions - is likely to be more effective.⁴² Similarly, corrective strategies are also likely to vary in their ability to dispel scepticism across different issues depending on the source(s) of science denial.⁴³ Therefore, further efforts to target sceptics are needed to improve understandings about these relatively diverse small groups.

Despite these limitations, our analyses make important contributions to existing understandings about the influence of trust in science over scepticism on climate change and COVID-19 vaccination. We find strong evidence that the majority of climate sceptics and antivaxxers, who are sceptics on one issue but not both, are driven by a localised distrust in science, whereas, for double sceptics, scepticism appears to be more autonomous of trust in science and deeply rooted in underlying sceptical worldviews.^{11,17,26} This latter proposition could be tested further by exploring whether our 'double' sceptics also hold sceptical attitudes towards a wider range of potentially controversial scientific practices such as genetically-modified crops, nuclear energy, fracking and wind turbines and broader anti-vax sentiments or scepticism towards conventional medicine. Given that antivax attitudes have immediate personal repercussions one might also try to separate out scepticism regarding policy interventions from scepticism that impacts directly on one's person and one might expect whether there are groupings of issues associated with what we call here single sceptics.

Our data also suggest that for the vast majority of climate sceptics and antivaxxers, i.e., those who are not sceptics on both issues, sceptical attitudes are also related to issues such as energy knowledge, perceived economic hardship and precautionism as well as distrust of scientists. The distinction between double and single sceptics has important implications for public attitudes towards climate policy and efforts to reduce emissions. While previous research shows that it is difficult to erode sceptical attitudes that are psychologically motivated,^{11,17,25} our findings suggest that efforts to build trust in scientists, public education campaigns and targeted economic support could help erode scepticism (at least among single sceptics) and increase compliance with behavioural remedies to mitigate climate change and the pandemic among most climate sceptics and antivaxxers.

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