
# Does public knowledge of climate change really matter in Australia?

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# Does public knowledge of climate change really matter in Australia?

Abstract

Replicating questions on climate change and polar knowledge from the United States, this study examines the impact of climate related facts for predicting acceptance of anthropogenic climate change, and for predicting Green voting in Australia. Analysis of national survey data from the Australian Survey of Social Attitudes show that the likelihood of Green voting increases with climate knowledge. Climate-related knowledge is also positively associated with acceptance of anthropogenic climate change, but the effect of knowledge is moderated by party political identification. Greens, Labor Party identifiers and politically un-affiliated Australians align more closely with the scientific consensus on climate change as their climate knowledge increases. However, climate knowledge has no effect on the climate change attitudes of Liberal and National party identifiers. Climate knowledge also interacts with gender. Climate knowledge has a stronger association with anthropogenic climate change beliefs among women than it does among men. These findings suggest the information deficit model of science communication is likely to be efficacious among supporters of politically progressive parties in Australia, but less so among political conservatives.

**Does climate knowledge matter?**

## Introduction

The consensus position of climate scientists regarding anthropogenic climate change (ACC) is well established. According to estimates, between 90 and 100 per cent of climate scientists agree that ACC is occurring (Powell, 2015; Cook et al., 2013; Anderegg et al., 2010; Doran and Zimmerman, 2009; Oreskes, 2004), with a recent survey claiming 97 per cent of published climate scientists hold that global warming has mostly anthropogenic causes (Cook et al. 2016). On the face of it, greater public awareness of the consensus position of climate scientists should be associated with greater agreement that anthropogenic climate change is occurring. However, the association between climate change knowledge and acceptance of ACC is not straightforward (e.g. Hamilton 2011; Hamilton, Cutler and Schaefer 2012; Kahan et al. 2012; Kahan 2015). Most people are not climate scientists, nor able to access or interpret relevant scientific evidence relating to climate change. Public opinion on climate change to a large extent seems to depend upon what people *believe* rather than know about climate change. Further, acceptance of anthropogenic climate change varies considerably according to one's sources of news and information (e.g. Carmichael et al. 2017; Bacon 2013), level of education (Hamilton 2011; Hamilton et al. 2015), world views (e.g. Kahan et al. 2012) and political party identification.

Citizens of the United States and Australia are polarised politically over ACC. In the United States, Democrats and Republicans are strongly divided (e.g. Wood and Vedlitz, 2007; Jacques et al., 2008; McCright and Dunlap 2010; 2011a, 2011b; Hamilton et al., 2015; Hamilton 2016), while in Australia similar divisions are apparent between supporters of the Greens and Labor parties on one hand and the Liberal and National parties on the other (Fielding et al. 2012; Tranter, 2011; Tranter and Booth, 2015). In the United States,

researchers have found political polarisation on climate beliefs also varies according to education level and knowledge of climate-related facts (e.g. Ehret et al. 2017; Hamilton et al. 2012, 2015), with important implications for the communication of climate science (Hamilton and Fogg 2019). In a partial replication of Hamilton's work in the US, this research examines how knowledge of climate change and political party identification interact to predict ACC beliefs in Australia. It also extends previous research on Green voting by considering how climate-related factual knowledge influences voting for the Greens in Australia.

*Climate Change Knowledge*

Participation in the democratic process requires a politically informed citizenry (Dahl 1982). As Rapeli (2014, 18) puts it, 'an enlightened public' is 'a prerequisite for the democratic form of governing.' Political knowledge enhances participation in politics, promotes political tolerance, and enables citizens to form 'stable, consistent opinions on a broad array of issues' (Delli Carpini and Keeter 1996, 219). Jennings (1996, 229) distinguish three types of 'factual' political knowledge: knowledge of 'the mechanics of government and politics'; knowledge of 'ongoing events and political developments'; and 'historical facts' (1996, 229). Similarly, for Delli Carpini and Keeter (1996, 10), political knowledge is 'the range of factual information about politics that is stored in the long-term memory', while for Rapeli (2010, 27), it is the 'command of verifiable facts related to politics'. Delli Carpini and Keeter (1996, 219) claim that informed citizens are able to 'identify their true interests and connect these with their political attitudes'. Although many voters experience difficulty correctly answering basic factual questions about politics (McAllister 1998; Tranter 2007).

A similar rationale underpins the communication of climate science to the public in a given society. Scientific findings relating to climate change are communicated via mass and other

media with the aim of informing 'the public'. Informed citizens should then be better placed to act on climate related issues, such as reducing carbon emissions by using less energy. This 'information-deficit model' (Suldovsky 2017), implies that the 'failure of the public to possess a clear understanding of climate science leads to a fundamental misunderstanding of the topic, and underlies the difference between the scientific and public understanding of it" (Brulle et al 2012: 174-5). As Hamilton and Fogg (2019, 10) point out (citing Cook et al. 2017, Farrell et al. 2019 and van der Linden et al. 2017), 'Experimental studies that find opinions changing after provision of information give support to this view, as does recent work on "inoculating" people against misinformation'. Hamilton and Fogg (2019, 10) argue that the 'positive effects of education, knowledge or science literacy on ACC acceptance' found in non-experimental studies (e.g. Ehret et al. 2017; Hamilton et al 2012, 2015) also support the information deficit model.

The deficit model suggests that resistance to information from climate scientists is due to an inability to comprehend the evidence. However, Huxster et al. (2018) warn of the need to distinguish 'knowledge' from 'understanding'. They suggest one *understands*

> …a subject (issue, concept, theory, …) only if one grasps how a constellation of facts relevant to that subject are related to one another (causally, inferentially, explanatorily, &c.) in such a way as to be able to make new connections or draw new inferences with novel information. As a result, the object of understanding is always a body—and never a single piece—of information. (Huxster et al. 2018, 759).

Many scientists and science communicators do not engage effectively with the public, with climate scientists often reluctant to engage in public debates (Besley and Nisbet 2013; Besley and Tanner 2011). This can impede scientists' ability to 'persuade the lay public of the correctness of scientific conclusions' (Lewandowsky et al. 2015, 9). It also potentially undermines the influence of scientific evidence in the development of government policy in contemporary democracies (Leith et al. 2017).

Besley and Nisbet (2013: 647-655) surveyed scientists regarding public understanding of science, finding scientists tend to perceive the public as homogenous, with 'education deficit'

viewed as a barrier for public understanding (Simis et al. 2016). Addressing this knowledge deficit remains the dominant scientific communication goal (Peters and Dunwoody 2016), at least partly to control the delivery of science informed messages to policy makers and the public in an era where 'fake news' has the potential to undermine evidence-based arguments. In fact, Lester and Foxwell-Norton (in press) argue science communicators need to recognise that the communication of science is but one domain of legitimacy and authority in environmental debates.

The association between climate change knowledge and ACC acceptance is complex, as it interacts with other factors, such as education and political party identification. In the United States, political polarisation over climate change increases with higher levels of self-reported climate knowledge, and with higher educational attainment (Hamilton 2011; Hamilton et al. 2015). Hamilton et al. (2015) show that political conservatives in the US are *less* accepting of anthropogenic climate change as their education level and knowledge of climate change increases, while informed and educated liberals become more accepting. Lewandowsky and Oberauer (2016, 217) found that 'general education and scientific literacy do not mitigate rejection of science, but, rather, increase the polarisation of opinions along partisan lines.' Kahan et al. (2012, 732) also found that 'members of the public with the highest degrees of science literacy and technical reasoning capacity were not the most concerned about climate change. Rather, they were the ones among whom cultural polarization was greatest.' Among liberal Democrat party identifiers who adopt progressive positions on climate change, higher levels of 'ordinary climate science' knowledge is associated with beliefs that global warming is mainly due to the burning of fossil fuel, yet among conservative Republicans, greater science knowledge is associated with increasing scepticism of such claims (Kahan 2015, 27).

In the United States (and I expect in Australia), polarisation over scientific findings arises when issues challenge worldviews, such as the importance of the free market (Kahan 2015; Lewandowsky et al. 2016). Public trust in climate scientists is also critical for communicating climate science. Democrats and independents are far more likely than Republican or Tea Party identifiers to trust climate scientists as a source of information about climate change (Hamilton et al. 2015; 2016). Politically charged and divisive terms such as 'climate change' and 'global warming' also influence attitudes, as they have become shorthand for partisan positions on political issues (Hamilton 2015). While Weber and Stern (2011, 315) acknowledge 'public understanding is affected by the inherent difficulty of understanding climate change', they also note the 'continuing societal struggle to shape the frames and mental models people use to understand the phenomena.'

Knowledge of climate change varies according to social background. The literature on gender and environmentalism suggests women are more likely than men to hold pro-environmental attitudes and engage in pro-environmental behaviour (Zelezny et al. 2000; Dietz, Dan and Shwom 2007). Climate scepticism is higher among men in several Western countries (Tranter and Booth 2015), while in Australia, women are more concerned about environmental issues in general, and about climate change in particular (Tranter 2014; 2018). Women score higher than men on climate change knowledge scales in the United States (McCright 2010), in contrast to measures of general scientific and environmental knowledge where men score higher (Hayes 2001). Examining a series of opinion poll data, McCright (2010, 66) found women were more concerned than men about climate change, a finding that was 'not accounted for by differences in key values and beliefs or in the social roles that men and women differentially perform in society'.

*Climate Knowledge in Australia*

While considerable research has been conducted in Australia on public attitudes regarding climate change (e.g. Fielding et al. 2012; Tranter 2011; 2014; 2017; 2018; Kousser and Tranter 2018), less is known about the association between climate change knowledge and acceptance of ACC. As we have seen, knowledge of climate change is associated with climate change beliefs in the US, but this association varies considerably according to political partisanship (e.g. Lewandowsky and Oberauer 2016; Hamilton 2015). In Australia, men score higher than women on self-assessed measures of climate change, with low self-assessed climate knowledge linked to sceptical beliefs about ACC (Tranter 2017; Tranter 2018). What has not been explored in Australia is how f*actual* rather than self-rated climate knowledge is associated with accepting ACC.

In keeping with Firebaugh's (2008, 90) 'replicate where possible' rule, I repeat aspects of Hamilton's (2015, 2016) research on polar knowledge and public beliefs in anthropogenic climate change. In recent years replication has been the subject of vigorous discussion in various science disciplines (e.g. see *Nature* 2014) and in the social sciences (e.g. see Finkel et al. 2015). Recent social psychological research on the communication of climate risks demonstrates the importance of replicating research findings (see Ballard and Lewandowsky, 2015; Sleeth-Keppler et al. 2019).[i] The current research is what Freese and Peterson (2017, 152) refer to as a 'generalisation' study, a form of replication where 'the original study provides a premise for research trying to evaluate whether similar findings may be observed consistently across different methods or settings'. I explore whether knowledge of climate-related facts is related to ACC beliefs in Australia, as it is in the USA.

I analyse nationally representative survey data from Australia to explore a) the social and political correlates of climate change knowledge, b) how knowledge of climate change is associated with climate change beliefs, and c) voting for the political party most supportive of action on climate change, the Australian Greens. The following research questions are examined.



**Research Questions**

1. *How knowledgeable are Australians compared to Americans on climate-related issues?*
2. *How well does knowledge of climate related facts predict ACC beliefs in Australia?*
3. *How strongly associated with ACC beliefs are climate knowledge, social background and political party identification?*
4. *To what extent do ACC beliefs, climate knowledge, social background and political party identification influence Green voting in Australia?*

**Data and Method**

Data are from the 2017 Australian Survey of Social Attitudes (AuSSA), a national social survey designed to be representative of the Australian adult population. The AuSSA sample was randomly selected from the Australian Electoral Roll 'by federal electoral division in proportion to the size of the division versus the total enrolled' (Blunsdon et al. 2018). A sample of 5000 people was selected and administered in 4 waves of 1,250 by mail survey. After ineligibles were removed, a response rate of 28 per cent was achieved (n = 1,317).

The author commissioned modules of climate change questions for the AuSSA from 2014 to 2017. Several of Hamilton's (2015) questions were replicated in the 2017 AuSSA by the

author, including polar knowledge questions. While there are similarities between the United States and Australia regarding the strong political divisions over anthropogenic climate change, replication of Hamilton's polar knowledge questions allow comparisons of the level of climate related knowledge in each country. The inclusion of polar knowledge questions in an Australian survey also enable the estimation of associations between climate related facts and acceptance of anthropogenic climate change in Australia, again, facilitating comparisons with the United States.

Several dependent variables are examined. The first measures climate change attitudes based on the question *'Which of the following statements do you personally believe'* and contrasts belief in ACC (i.e. climate change is happening now and mainly caused by humans = 1) with other responses (i.e. climate change is happening now but has mainly natural causes + climate change is not happening now + don't know = 0). Responses to this question are presented in Table 1 for 2014, 2015 and 2017. The second dependent variable models self-assessed knowledge of climate change from the question '*How much do you feel that you understand about climate change - would you say a great deal, a moderate amount, only a little, or nothing at all?*' (scored 1 = nothing at all to 4 = a great deal).

The third dependent variable is based on responses to questions that replicate three of Hamilton's (2015) polar knowledge questions. Unlike some knowledge questions that refer directly to climate change and are politically polarising, the polar questions are claimed to be apolitical. As Hamilton (2015, 100) suggests, 'awareness of geography or the sea/land ice distinction, unlike other basic facts such as ice decline, appears unrelated to respondents' politics or climate-change beliefs.' Slight adjustments to question wording were made to the original items to change descriptions of distance (i.e. from miles in the USA to kilometres in Australia). The distribution of the polar items is presented in Table 2. The polar knowledge questions here do not comprise a comprehensive measure of climate change knowledge.

However, as Hamilton (2015, 100) acknowledges, the 'polar knowledge score defined as the number of correct answers among sea level, North Pole and South Pole questions…provides a limited but analytically useful marker for *knowledge*.'

Finally, voting behaviour is measured with the question '*Thinking back to the last general election in July 2016 - Which party did you vote for*?' (responses: Labor Party [ALP], Liberal Party, National [Country] Party, Greens, Other party [please specify]). A binary dependent variable was created with Green voting scored 1; all other parties were scored 0.

Binary and ordinal logistic regression analyses are performed using STATA version 15. Binary regression is used to examine ACC beliefs versus other responses regarding climate change, and individual items that comprise the polar knowledge scale. Ordinal logistic regression is employed to examine self-assessed climate knowledge and the polar knowledge scale.

As McCright et al. (2016) found, left of centre political ideology is associated with stronger support for action to mitigate climate change. The political party identification question in the AuSSA asks '*Do you usually think of yourself as close to any particular political party and, if yes, which party is that*?' Following Hamilton, Hartter and Saito (2015) and Kousser and Tranter (2018), a scale variable is operationalised in the regression models as a parsimonious measure of political party identification. The scale scores Greens =1; Australian Labor Party [ALP] = 2; No party affiliation = 3; Liberal Party or National Party = 4. The party identification coding follows the way party identifiers align on a 0 to 10 left-right ideology scale. While the AuSSA does not contain such a scale, mean scores for respective political party identification responses from the 2016 Australian Election Study (McAllister et al. 2016), show that Green partisans (Mean 2.71) rate themselves to the left of

Labor (3.94), non-party identifiers (4.74), and Liberal (6.23) and National (6.29) party identifiers. The Liberal and National parties are members of a coalition in Australian federal politics, with their partisans very closely located on the left-right scale based on Australian Election Study data. Liberals and National are therefore combined as one category. The small number of respondents affiliated with other parties (n = 32) and missing cases on the party identification question (n = 56) were coded 2, along with the modal category of non-identifiers.

Five models are presented for the binary logistic regression analyses of belief in ACC compared to other responses regarding climate change in Table 4. Model 1 includes only the polar knowledge scale (centred at its mean) and Model 2 social background variables, the influence respondent sex (1= women) age (in years), degree (1/0), household income of $100,000 or more (1/0), no religious affiliations (1/0), living in a large city (1/0) and being born in Australia (1/0).

Model 3 includes only the party identification (party ID) scale (centred at its mean) and Model 4 is the full model that includes all main effect variables from Models 1 to 4. Model 5 adds three interaction terms, for women by the polar knowledge scale, women by the political party ID scale, and party ID by polar knowledge. Descriptive statistics for the dependent and independent variables are shown in the Appendix.

[Table1 about here]

## Results

Table 1 contains responses to questions gauging attitudes toward climate change, and self-assessed knowledge of climate change. In 2017, approximately two thirds (65%) of Australians believed that climate change is occurring and has mainly anthropogenic causes, a significant increase from 61 per cent in 2014 (Fisher's Exact Test $p < .0001$). The 2017 result was slightly lower than that for 2015 at 67 per cent, although this difference does not represent a significantly different change in ACC acceptance at the 95 per cent level (Fisher's Exact Test $p > .302$).

While in 2014, 29 per cent of Australians claimed climate change has natural causes, this decreased to 13 per cent in 2015, before rising again to 19 per cent in 2017. The change between each year was highly significant (Fisher's Exact Test $p < .0001$). The level of outright rejection of climate change is quite low, fluctuating between 3 and 5 per cent across the three samples, with a significant decline from 2015 to 2017 in the percentage of those believing climate change is not occurring (Fisher's Exact Test $p = .016$). However, the proportion of Australians claiming that they 'don't know' whether climate change is occurring or not is around twice as high in 2015 and 2017 compared with 2014, based on these estimates. While around two thirds of Australians believe climate change has anthropogenic causes, about one third either believe that climate change is a 'natural' phenomenon or are unsure what they believe.

### *Climate Change Knowledge*

The knowledge questions examined here replicate those asked on several regional or nationwide US surveys (e.g., Hamilton 2015). The most definitive US results for comparison with Australia are those reported in Hamilton (2018). Comparing self-rated climate change

knowledge, 17 per cent of Australians claim to know a great deal about climate change compared to 24 per cent of Americans (Table 2). A further 48 per cent of Australians believe they possess a moderate amount of knowledge, once again, less than the 57 per cent of Americans (Table 2).

Three quiz questions measure basic knowledge of the composition of the North and South Poles, and the implications of ice melt for sea level rise (Hamilton 2015). Forty four percent (44%) of Australians and Americans correctly identified the North Pole as a thin layer of ice floating over a deep ocean (Table 2), while a slightly higher percentage of Americans (52%) than Australians (49%) correctly identified the South Pole as a thick layer of ice over land. Greater variation is apparent for the 'ice melt' questions (Australia 42%; USA 34%). Notably, however, for each of these quiz questions, Australians were far more likely than Americans to claim they did not know the correct answer. For example, 36 per cent of Australians for the ice melt question, compared to only 12 per cent of Americans. The lower proportions of 'don't know' responses for Americans could indicate they are more likely to guess.

[Table 2 about here]

***Predictors of Polar Knowledge***

The social and political background of responses on the polar knowledge and self-assessed climate knowledge dependent variables are examined in Table 3 using ordinal logistic regression. Self-assessed knowledge is based on the question '*How much do you feel that you understand about climate change - would you say a great deal (4), a moderate amount (3), only a little (2), or nothing at all (1)?*' The polar knowledge scale ranges from 0 to 3 (Responses: 0 = 28%; 1 = 29%; 2 = 27%; 3 = 17%).

[Table 3 about here]

Australian women score *lower* than men on both the self-assessed and polar knowledge scales, controlling for other influences. Increasing age is associated with higher polar knowledge, but age is not associated with self-assessed knowledge, while tertiary graduates score higher than non-graduates on both dependent variables. Those born in Australia (OR 1.4) score higher on the polar scale, but do not believe they are more knowledgeable than people born elsewhere.

A borderline statistically significant association is apparent for party identification and the polar knowledge dependent variable (1.14; p = .049), but the party identification effect is far stronger for self-assessed knowledge (OR 1.32; p <.001), such that moving from conservative to progressive party identification is associated with higher perceived knowledge of climate change. I also consider the association of different climate change beliefs as a predictor of polar and self-rafted knowledge. The results indicate that those claiming they 'don't know' whether climate change is happening, not only believe they have poor knowledge of climate change, they *are* less knowledgeable about polar facts. Other things being equal, polar knowledge scores are similar for those who believe climate change has anthropogenic causes, that is 'natural' or those who claim it is not happening. Australians who reject climate change show higher odds on the self-rated knowledge dependent variable, but the effect is of borderline significance (OR 1.9; p = .053).

These results are largely consistent with Tranter's (2018) findings for self-assessed climate change knowledge. Also, similar to McCright's (2010) findings from the United States, Australian men score higher than women do on self-rated understanding of global warming. Yet, unlike McCright's (2010) findings, in Australia, men score higher than women on factual questions relating to climate change.

*Polar knowledge and believing in anthropogenic climate change*

Binary logistic regression models show ACC acceptance regressed on polar knowledge, political party identification and social background variables (Table 4). The likelihood ratio chi-squared tests in Table 5 estimate the utility of each model for predicting ACC beliefs. Interaction terms for women * polar knowledge, women * party identification, and party identification * polar knowledge were all significant in the regression models. Predicted probabilities are presented in Figures 1 to 3 (based upon Model 5; Table 4) to illustrate the nature of these interaction effects.

[Table 4 about here]

Model 1 indicates that polar knowledge is significantly associated with acceptance of ACC (OR 1.33), but the pseudo $R^2$ (McFadden's) indicates relatively poor model fit compared to Models 2 to 3. Nevertheless, Model 1 indicates that believing in ACC is more common at higher levels of polar knowledge. Socio-demographic variables appear to offer a better fit with these data ($R^2$ .08), with statistically significant positive associations for women (OR 1.6), tertiary graduates (OR 1.9) and those who are not affiliated with any religious denomination (OR 1.8), while younger Australians are more likely than their elders to believe climate change has anthropogenic causes (OR 0.98). Australians living in rural areas are less likely to agree with the scientific consensus on climate change than those living elsewhere (0.7). Rural voters tend to vote for conservative political parties in Australia, but the rural estimate remains significant even when party identification is controlled (Model 4).

Model 3 indicates that the political party identification scale has a strong association with climate change attitudes (OR 2.34), with ACC beliefs more likely moving from the mean of the scale toward Labor and the Greens, and less likely toward Coalition identifiers. Model 4 shows that even when all independent variables are included in the regression equation, political party identification and knowledge effects remain strong.

Finally, the three interaction terms are illustrated graphically in Figures 1 to 3. Acceptance of ACC is far more likely to increase among women compared to men as polar knowledge increases (OR 1.49). Women and men who score zero on the polar knowledge scale vary little in their ACC beliefs, however the gender gap in climate beliefs widens as climate-related knowledge increases (Figure 1). The association between climate change beliefs and party identification also varies for men and women (OR 1.55), with women more likely than men to accept ACC (Figure 2). Coalition men and women do not vary significantly in their ACC beliefs, but there are statistically significant gender differences among non-identifiers, and Labor and Greens identifiers; in each case, women are more accepting of anthropogenic climate change than men are.

There is also an important interaction effect for party identification by polar knowledge on (OR 1.48). The predicted probability of believing in anthropogenic climate change is positively associated with polar knowledge among non-identifiers, Labor, and Greens identifiers (Figure 3). However, the horizontal plot for Coalition identifiers, indicates that acceptance of ACC does not change as polar knowledge increases. Climate-related knowledge has no impact upon accepting the scientific consensus on climate change among political conservatives.

The likelihood ratio chi squared tests indicate the model fit is diminished by dropping either polar knowledge, the social background variables, or political party identification from

Model 5. Dropping the three interaction variables also results in a poorer fit with these data. However, the likelihood ratio tests also show the party identification scale fits these data far better than social background, or polar knowledge for modelling beliefs in anthropogenic climate change (Table 5).

[Figures 1 – 3 about here]

***Voting for the Australian Greens***

The dichotomous Greens voting variable is examined in Table 6 using binary logistic regression analysis, using similar models to those in Table 4. Previous research has shown that compared to Labor and Liberal/National party supporters, Australia Greens supporters tend to be younger, more likely to live in cities and to be tertiary educated, although less likely to claim a religious affiliation (Wilson 2002, Bean and McAllister 2009; Miragliotta 2013). In the models presented in Table 6, respondent age is measured as several dummy (1/0) variables rather than a continuous measure, as the age/voting relationship is non-linear. Belief in anthropogenic climate change is also operationalised as a dummy independent variable in these models. Finally, a variable prioritising government action on global warming versus economic growth is derived from the question: '*Which of the following do you believe is the most important for the future of Australia?*': Australian government policy should prioritise economic growth (53%), scored 0; Australian government policy should prioritise the reduction of global warming (47%) scored 1.

[Table 5 about here]

The likelihood of voting Green increases with polar knowledge (Model 1), with the odds of Green voting increasing by 1.32 above the mean for a unit change on the polar knowledge scale. Social background effects are apparent, with women showing 50 per cent higher odds of voting Green than men (OR 1.5) in Model 2, although the gender effect is non-significant

in the full model (Model 5). Australians aged 30-49 show higher odds of voting Greens than either the youngest age group (18-29) or those aged 60 and over, while consistent with previous Australian research (Tranter 2014), the tertiary-educated (OR 2) and the non-religious (OR 3.2) are more likely to vote Green. Age, education and religion effects also remain significant in the full model (Model 5).

Not unexpectedly, Model 3 indicates that accepting ACC is strongly associated with Green voting (OR 7.3). Yet by far the strongest effect is observed for the government policy variable. The odds of voting Green among those who prioritise action on global warming, are 12 times larger than for those who prioritise economic growth (OR 11.8). Interestingly, prioritising global warming renders the impact of both polar knowledge and ACC acceptance weaker and non-significant in Model 5. Other analyses (not shown here) confirm that these changes are not due to the influence of social background variables. The most important indicator of voting Green is believing that the Australian government should reduce global warming over boosting economic growth. Likelihood ratio chi square tests confirm the policy priority variable is most strongly associated with Green voting, followed by social background variables. Dropping either ACC beliefs or polar knowledge from the full model (Model 5) does not result in a statistically significant difference in model fit (Table 7).

**Discussion**

Replicating survey questions employed by Hamilton (2015, 2016, 2018), I find Australians score lower than US citizens on *self-rated* climate change knowledge. However, on climate-related *factual* questions about the North and South poles, Australians and Americans perform similarly, with Australians scoring somewhat higher on the implications of melting ice for rising sea levels.

Hamilton (2015, 89) found that 'responses to climate linked factual questions, such as whether Arctic sea ice area has declined compared with 30 years ago, are politicized as if we were asking for climate change opinions.' However, *scientific facts* 'such as whether the North Pole is on land or sea ice' were not politicised among US citizens (2015, 89). A key expectation in this research was that as knowledge of polar facts rises, Australians' views on climate change should align more closely with the consensus position of climate scientists (Cook et al. 2016; Powell, 2015; Cook et al., 2013; Anderegg et al., 2010; Doran and Zimmerman, 2009; Oreskes, 2004). Indeed, I find a positive main effect for polar knowledge as a predictor of ACC beliefs. Yet, knowledge of polar facts also interacts with political party identification as a predictor of ACC beliefs. The propensity to accept ACC increases with polar knowledge among Greens, Australian Labor Party identifiers and those who do not identify with any political party. However, knowledge has no effect on ACC acceptance among Liberal and National identifiers. It seems that acceptance of anthropogenic climate change is unrelated to climate change knowledge among political conservatives in Australia.

Hamilton and Fogg (2019, 8) also found an interaction effect for political party by polar knowledge, indicating that Republicans are not more likely to accept ACC as their polar knowledge increases. Hamilton and Fogg (2019)[ii] and my Australian findings appear to indicate that 'physical-world knowledge' such as polar facts have also become politicised. Perhaps through *assimilation bias* (e.g. Corner et al. 2012; Ehret et al. 2017; McCright and Dunlap 2011) or a related process, ideologically conservative citizens in both countries interpret factual questions about polar regions as associated with rising sea levels. Political conservatives link such questions to anthropogenic climate change, so that polar facts become politicised. These findings are intriguing, although tentative, with further research required to establish if they can be replicated in their respective countries.

In broad terms, the Australian findings are consistent with Lewandowsky and Oberauer (2016, 220, citing Cook and Lewandowsky, 2016), who found 'participants who strongly supported free market economics lowered their acceptance of human-caused global warming in response to information about the climate consensus'. The lack of a polar knowledge effect for Liberal and National Party identifiers could be underpinned by beliefs that climate change does not constitute a serious global risk. It could also reflect a form of identity protection (whether conscious or otherwise) among conservative Australians, if they 'form distinct attitudes toward risk in a manner that protects from interference the activities on which their identities depend' (Kahan et al. 2007, 498). As Lewandowsky and Oberauer (2016, 217) put it, 'people tend to reject findings that threaten their core beliefs or worldview'.

Social background impacts polar knowledge. Australian men rate themselves higher than women do on self-assessed climate knowledge, with men also scoring higher on factual knowledge questions. These Australian results are consistent with Hayes' (2001) environmental knowledge findings for the United States, the UK, Norway, Netherlands, Germany and Japan. Further, tertiary educated Australians score higher than non-graduates on both self-assessed climate knowledge and polar knowledge. While no association is evident for age and self-assessed knowledge, older Australians tend to score higher on factual climate-related questions. The latter finding is consistent with higher scores among older citizens on environmental knowledge in several Western countries (Hayes 2001), climate change knowledge in the United States (McCright 2010) and political knowledge in Australia (McAllister 1998; Tranter 2007).

While Haynes (2001) found no interaction between gender and scientific knowledge in predicting environmental attitudes, a gender by polar knowledge interaction is apparent for

accepting ACC in Australia. Acceptance of anthropogenic climate change increases with polar knowledge among both men and women, but in Australia the effect is far stronger among women. Zelezny et al. (2000, 454) found women 'reported stronger ecocentrism (concern for nature, the biosphere, and all living things) than males'. It appears that Australian women may be more receptive than men to the climate consensus position because they prioritise different value (McCright, 2010).[iii]

The Australian Greens champion action on climate change and proffer more progressive climate policies than the major parties (Rootes 2011), so voting Green arguably represents a commitment to action on climate change. Tranter (2007) found politically knowledgeable Australians were more likely to vote Green than for other parties in the Senate (Tranter 2007). This research extends previous findings on Green voting, revealing that climate-related factual knowledge is correlated positively with Green voting. However, prioritising global warming over economic growth is by far the most important correlate of voting Green in Australia, surpassing the effects of climate change beliefs and climate related facts.

*Limitations*

This study has potential limitations relating to the measurement of climate knowledge, political party identification and voting behaviour. First, the association between climate change knowledge and accepting ACC may be understated, because I measure climate-related polar facts rather than factual questions about climate change. Yet, as Hamilton (2015, 102) shows, responses to climate change knowledge questions (e.g. regarding Arctic ice decline or atmospheric $CO_2$ increases) 'behave as if we are asking for people's climate-change opinions, which have become acutely politicized…to the extent they serve as ideological or cultural markers.' For example, climate change sceptics may know the climate science consensus position (e.g. $CO_2$ emissions cause global warming) but reject such a claim

because it conflicts with their strongly held worldviews (Kahan 2015; Lewandowsky and Oberauer 2016). Directly measuring climate science facts to operationalise knowledge of climate change is, therefore, potentially problematic. Nevertheless, further research is required to establish whether responses to factual climate change questions are politically polarised in Australia, as they are in the United States.

Second, the measurement of party identification utilised here may overstate the association between political party identification and belief in ACC. Political party identification is measured in the AuSSA with the question '*Do you usually think of yourself as close to any particular political party and, if yes, which party is that?*' The addition of 'close to' in the AuSSA question may result in measuring a stronger form of attachment to political parties, compared to the Australian Election Study question *'Generally speaking, do you usually think of yourself as Liberal, Labor, National or what?'* (McAllister et al. 2016). Finally, unlike the Australian Election Study, the AuSSA does not measure voting behaviour precisely, as it does not distinguish voting in the House of Representatives from voting in the Senate.

*Conclusion*

Some scholars question the value of persisting with the 'deficit model' of climate science communication. As Hornsey and Fielding (2017, 459) argue, 'increasingly, theorists understand there are limits to this approach, and that if people are motivated to reject science, then repeating evidence will have little impact'. Ehret et al. (2017, 272) recommend integrating information deficit models with what they call 'ideological consistency' models, as '[W]ithout changing the messaging from political elites, simply communicating more about scientific findings will have little effect on partisans.' Hamilton and Fogg (2019) have

also shown that the relationship between climate knowledge and ACC beliefs is nuanced. They find evidence consistent with both information deficit and information filtering models in the United States[iv]:

> Among Democrats and Independents, greater physical-world knowledge is associated with…higher probabilities of agreeing with scientists on ACC. These patterns are consistent with information deficit and its corollary that improving science communication could shift views – for some people. Among Republicans, on the other hand…beliefs about climate change may be less responsive to climate communication, if that conflicts with firmly held political views (Hamilton and Fogg 2019, 11).

The utility of replicating research is demonstrated here, as several of the Australian findings support Hamilton's American research. Hamilton and Fogg (2019) argue that although its limitations should be recognised, the deficit model should not be abandoned. Similarly, the absence of an association between climate related facts and acceptance of ACC among political *conservatives* in Australia, suggests that for many people, increasing public knowledge of climate change is unlikely to shift their climate change beliefs. It seems Australia and the United States are very similar in this regard.

What to do? While the misinformation campaigns of climate denialists are extremely damaging to the dissemination of climate science, social psychologists offer a range of countering tactics (e.g. see Cook 2017). Perhaps most importantly, the political divisions over climate change in the United States and Australia must be addressed. Brulle et al. (2012, 169) argue that the 'political mobilization by elites and advocacy groups is critical in influencing climate change concern.' Kousser and Tranter (2018, 107) found that cues from political leaders can shift public support for climate change policies, with voter polarisation decreasing under conditions of elite consensus, while Fielding et al. (2019) show citizens to

be 'more positive about climate change policies when they were endorsed by their political ingroup than when the same policy was endorsed by an outgroup'.

In addition to the information deficit approach of 'educating' citizens about climate science, it is important to engage with those who distrust climate science (and climate scientists). Emphasising the economic, environmental and social *benefits* of ameliorating climate change may be a beneficial strategy for shifting the climate beliefs of conservative citizens.

While the consensus among climate scientists on anthropogenic climate change is well documented, a concomitant consensus among political leaders is required to shift public attitudes and behaviour, and attenuate political polarisation on this critical issue, particularly in countries such as Australia and the United States. Climate communicators can play an important role in encouraging dialogue between rival political elites, and in highlighting the non-partisan benefits of mitigating anthropogenic climate change, in order to help build such a consensus.

Citizens of both the United States and Australia are deeply divided over climate change on the basis of their political allegiances. Further, knowledge of climate related facts is not associated with acceptance of anthropogenic climate change among Republicans in the US (Hamilton and Fogg 2019), nor among politically *conservative* Australians. Additional research is needed into how climate knowledge influences the acceptance of anthropogenic climate change, in countries where politics is not such an important determinant of one's stance on this critical global problem.

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[i] In two separate replication studies, the authors of an original research project failed to replicate their earlier findings (see Ballard and Lewandowsky, 2015; Sleeth-Keppler et al. 2019).

[ii] See Hamilton and Fogg (2019, 8), Table 2, 'Climate' dependent variable results.

[iii] The Australian findings indicate substantial gender differences over value priorities, with men (58%) generally more likely than women (47%) to agree that government policy should prioritise economic growth over global warming. Responses vary further when split by party allegiances, with 69 per cent of Labor women and 54 per cent of Labor men prioritising global warming, compared to 23 per cent of coalition women and 21 per cent of coalition men (non-partisan women 53%; men 45%).

[iv] Hamilton and Fogg (2019) refer to a range of related 'information filtering' models that refer to the 'selective acquisition of information…such as *biased assimilation* (Corner et al. 2012; Ehret et al. 2017; McCright and Dunlap 2011), *elite cues* (Brulle et al. 2012; Carmichael and Brulle 2017; Darmofal 2005), *motivated reasoning* (Kraft et al. 2015; Kunda 1990; Taber and Lodge 2006), *compensatory control* (Kay et al. 2009), or *cultural cognition* (Kahan et al. 2011).'

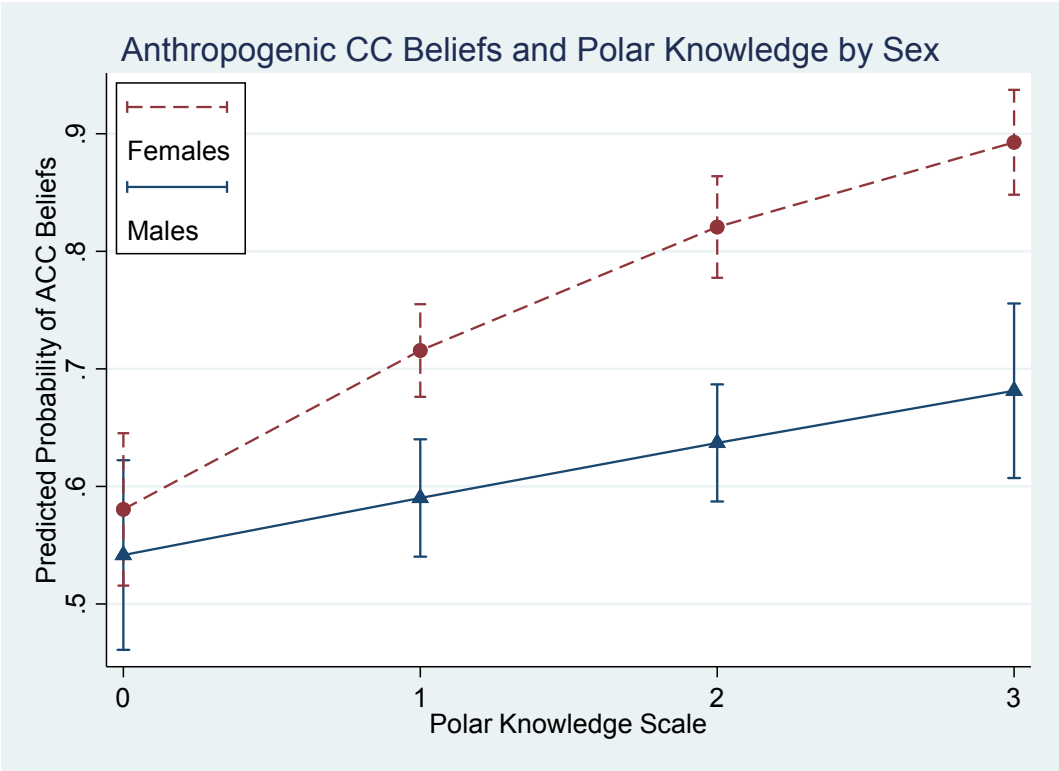


**Figure 1: Predicted Probabilities of ACC Beliefs and Polar Knowledge by Sex**

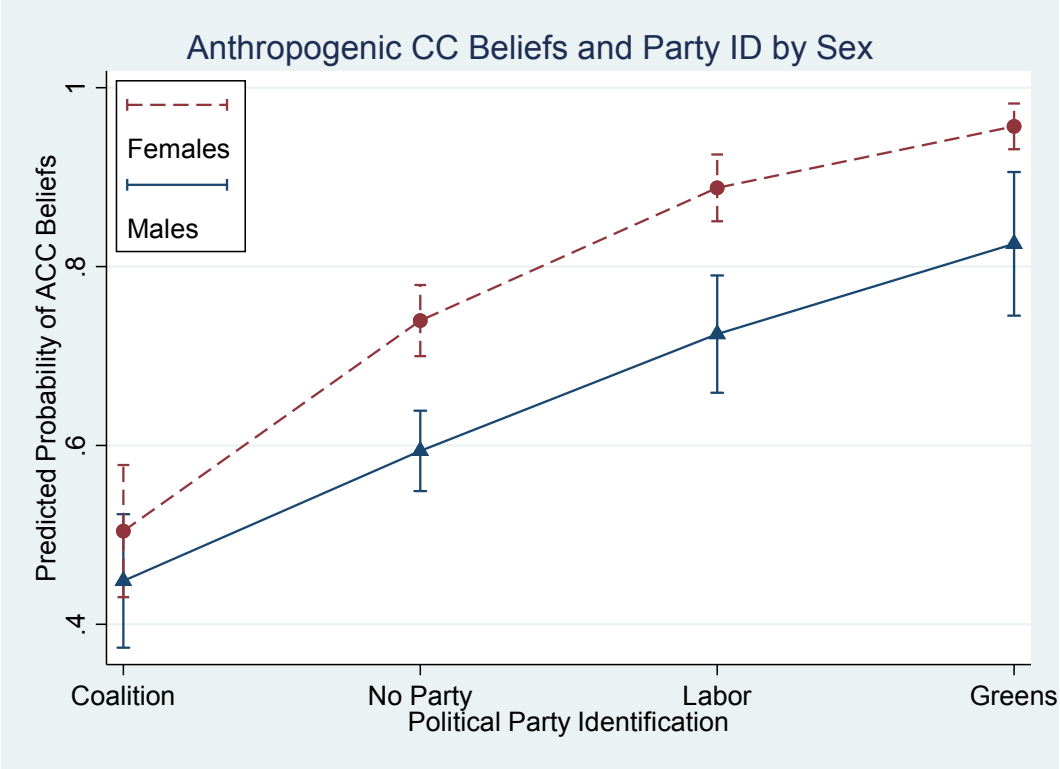


**Figure 2: Predicted Probabilities of ACC Beliefs and Party Identification by Sex**

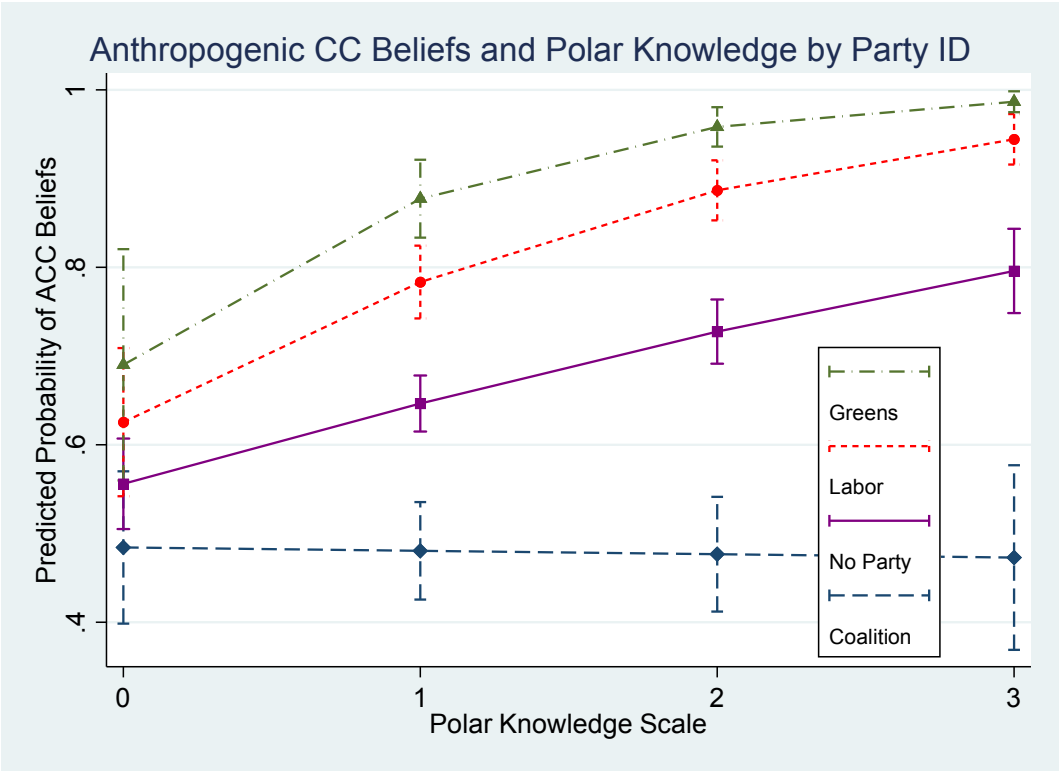


**Figure 3: Predicted Probabilities of ACC Beliefs and Polar Knowledge by Party ID**

**Table 1: Which of the following statements do you personally believe (per cent)**

| Year | 2014 | 2015 | 2017 |
|---|---|---|---|
| *Which of the following statements do you personally believe?* | | | |
| CC is happening now and is mainly caused by human activities | 61 | 67 | 65 |
| CC is happening now but is caused mainly by natural forces | 29 | 13 | 19 |
| CC is not happening now | 4 | 5 | 3 |
| I don't know whether climate change is happening or not | 7 | 15 | 13 |
| N | (1,380) | (1,148) | (1,262) |

Source: Australian Survey of Social Attitudes (2014; 2015; 2017)

**Table 2: Polar knowledge (per cent)**

| Which of the following best describes the… | *North Pole* | | *South Pole* | |
|---|---|---|---|---|
| | Australia | USA | Australia | USA |
| Ice a few metres thick floating over a deep ocean | **44** | **44** | 18 | 21 |
| Ice more than a kilometre thick over land | 25 | 38 | **49** | **52** |
| A mainly rocky, mountainous landscape | 4 | 7 | 5 | 14 |
| Don't know | 27 | 11 | 28 | 14 |
| Total | 100 | 100 | 100 | 100 |
| N | (1,262) | (1,411) | (1,262) | (1,411) |

| Which of the following possible changes would, if it happened, do the most to raise sea levels? | *Ice Melt* | | *Self-Assessed Knowledge* | | |
|---|---|---|---|---|---|
| | Australia | USA | | Australia | USA |
| Melting of land ice in Greenland and the Antarctic | **42** | **34** | A great deal | 17 | 24 |
| Melting of Glaciers in the Himalayas and Alaska | 4 | 13 | Moderate | 48 | 57 |
| Melting of Sea ice on the Arctic Ocean | 18 | 41 | A little | 31 | 16 |
| Don't know | 36 | 12 | Nothing | 4 | 2 |
| Total | 100 | 100 | Total | 100 | 100 |
| N | (1,263) | (1,411) | N | (1,259) | (1,411) |

Sources: Australian Survey of Social Attitudes (2017); Hamilton (2018).

**Table 3: Polar Knowledge compared with Self-Assessed Climate Knowledge (cumulative odds)**

| | Polar scale | Self-Assessed |
|---|---|---|
| Women | 0.6*** | 0.5*** |
| Age (years) | 1.011** | 1.0002 |
| Degree | 1.8*** | 1.6*** |
| Income $100K+ | 1.2 | 1.3 |
| No religious affiliation | 1.003 | 0.95 |
| Live in rural area | 1.3 | 1.1 |
| Born in Australia | 1.4** | 0.97 |
| Party ID (scale) | 1.14* | 1.32*** |
| *Which do you believe…* | | |
| CC is happening now mainly caused by humans | 1 | 1 |
| CC is happening but mainly natural causes | 0.8 | 0.8 |
| CC is not happening | 0.9 | 1.9 |
| Don't know | 0.3*** | 0.1*** |
| McFadden pseudo $R^2$ | .04 | .09 |
| N | (1,259) | (1,273) |

Notes: * p< .05; ** p< .01 *** p< .001.

Source: Australian Survey of Social Attitudes (2017)

**Table 4: Climate Change is happening now and is mainly Anthropogenic (odds)**

| Model | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| *Social Background* | | | | | |
| Women | - | 1.6*** | - | 1.7*** | 2.0*** |
| Aged (years) | - | 0.98*** | - | 0.98*** | 0.97*** |
| Degree | - | 1.9*** | - | 1.6** | 1.6** |
| Income $100K+ | - | 1.3 | - | 1.4 | 1.5 |
| No religious denomination | - | 1.8*** | - | 1.5** | 1.5** |
| Live in rural area | - | 0.7* | - | 0.7* | 0.7* |
| Born in Australia | - | 0.8 | - | 0.8 | 0.8 |
| Party ID scale (1-4) | - | - | 2.34*** | 2.15*** | 1.76*** |
| Polar knowledge scale (0-3) | 1.33*** | - | - | 1.36*** | 1.22* |
| Women * Polar knowledge | - | - | - | - | 1.49** |
| Women * Party ID | - | - | - | - | 1.55* |
| Party ID * Polar knowledge | - | - | - | - | 1.48*** |
| McFadden pseudo $R^2$ | .02 | .08 | .07 | .15 | .17 |
| N | (1,268) | (1,268) | (1,268) | (1,268) | (1,268) |

Notes: * p< .05; ** p< .01 *** p< .001.

Dependent variable: Anthropogenic Climate Change is happening =1; climate change is happening but 'natural' + climate change is not happening + don't know = 0.

Source: Australian Survey of Social Attitudes (2017)

**Table 5: Likelihood Ratio Tests for Models in Table 4**

| Model 5 less | Nested Variables | L.R. $\chi^2$ | df | p | Rank |
|---|---|---|---|---|---|
| Model 1 | Polar Knowledge | 22.74 | 1 | <.00001 | 3 |
| Model 2 | Social background | 104.35 | 7 | <.00001 | 2 |
| Model 3 | Party ID | 81.88 | 1 | <.00001 | 1 |

| Model 6 less | Nested Variables | L.R. $\chi^2$ | df | p |
|---|---|---|---|---|
| Model 5 | Interactions | 28.66 | 2 | <.00001 |

**Table 6: Green Voting in Australia (odds)**

| Model | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| *Social Background* | | | | | |
| Women | | 1.5* | | | 1.2 |
| Aged 18-29 (referent) | | 1 | | | 1 |
| Aged 30-49 | | 1.8* | | | 1.8* |
| Aged 40-59 | | 1.3 | | | 1.4 |
| Aged 60+ (referent) | | 1 | | | 1 |
| Degree | | 2.0*** | | | 1.5* |
| Income $100K+ | | 0.6 | | | 0.6 |
| No religious denomination | | 3.2*** | | | 2.5*** |
| Live in rural area | | 1.01 | | | 1.04 |
| Born in Australia | | 1.02 | | | 0.98 |
| Polar knowledge scale (0-3) | 1.32** | | | | 1.12 |
| Believe in ACC | - | - | 7.3*** | | 1.5 |
| Government should Prioritise GW over EG | - | - | - | 11.8*** | 7.6*** |
| McFadden pseudo $R^2$ | .01 | .08 | .08 | .15 | .20 |
| N | (1,151) | (1,151) | (1,151) | (1,151) | (1,151) |

Notes: ^ p< .1 * p< .05; ** p< .01 *** p< .001.

Dependent variable: Vote Australian Greens =1; other party = 0.

Source: Australian Survey of Social Attitudes (2017)

**Table 7: Likelihood Ratio Tests for Models in Table 6**

| Model 5 less | Nested Variables | L.R. $\chi^2$ | df | p | Rank |
|---|---|---|---|---|---|
| Model 1 | Polar Knowledge | 1.29 | 1 | .2569 | 4 |
| Model 2 | Social background | 37.27 | 8 | <.00001 | 2 |
| Model 3 | Party ID | 1.40 | 1 | .2369 | 3 |
| Model 4 | Policy Priorities | 55.03 | 1 | <.00001 | 1 |

**Appendix: Descriptive Statistics**

| | Mean | Std. | Range | N |
|---|---|---|---|---|
| *Dependent Variables* | | | | |
| Anthropogenic CC happening now | 0.64 | 0.48 | 1/0 | 1268 |
| Polar knowledge scale | 1.39 | 1.04 | 0-3 | 1254 |
| Self-assessed climate knowledge | 2.82 | 0.73 | 1-4 | 1273 |
| Green vote | 0.12 | 0.32 | 1/0 | 1151 |
| *Independent Variables* | | | | |
| Women | 0.55 | 0.50 | 1/0 | 1317 |
| Aged (years) | 55.15 | 17.04 | 1/0 | 1317 |
| Degree | 0.33 | 0.47 | 1/0 | 1317 |
| Income $100,000+ | 0.10 | 0.30 | 1/0 | 1317 |
| No religious affiliation | 0.43 | 0.50 | 1/0 | 1317 |
| Live country village/farm | 0.15 | 0.35 | 1/0 | 1317 |
| Born in Australia | 0.73 | 0.44 | 1/0 | 1317 |
| Party ID scale | 2.10 | 0.84 | 1-4 | 1317 |
| Prioritise GW or Economic Growth | 0.47 | 0.50 | 1/0 | 1317 |