



Research article

Why does the public support or oppose agricultural nutrient runoff regulations? The effects of political orientation, environmental worldview, and policy specific beliefs

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ABSTRACT

This research examines public acceptability of regulations to reduce agricultural nutrient runoff and curb Harmful Algal Blooms (HABs). We tested the effects of two novel policy specific beliefs including support for farmers' autonomy and support for external accountability. We also simultaneously tested the direct and indirect effects of political orientation and environmental worldview through a Direct Effect Model and a Mediation Model using structural equation modelling. Survey data were collected from 729 Ohio residents collected in November 2018. The specific regulatory policy measure we targeted is fines on excessive agricultural runoff. As hypothesized, autonomy beliefs negatively affect, and accountability positively affect support for fines. Both models revealed good fits. The direct effects of environmental worldviews political orientation were not supported. Instead, environmental worldviews indirectly increased support for fines through increased accountability beliefs and diminished autonomy beliefs. From the results, we suggest that when proposing suitable regulations for specific sites, policy makers and interest groups should be aware of differences in public support for farmer autonomy and external accountability, and that such differences are likely rooted in environmental worldviews. The study also suggests a need for coupled ecological and social studies that assess the likelihood of regional agricultural producers voluntarily adopting conservation practices and forecast the effectiveness of potential accountability measures.

1. Introduction

Facing increasing threats of nutrient pollution from agricultural runoff and the ensuing harmful algal blooms (HABs), governments in different parts of the world are using diverse methods, including regulatory policies to induce wide-spread changes in farming practices. However, people disagree on whether regulatory policies should be used in addition to existing market-based, educational, and technical assistance programs (Garnache et al., 2016; Shortle and Horan, 2013; Smith et al., 2018). In cultures that emphasize individual freedom, including the United States, regulations such as penalties, mandatory actions, and monitoring are often less acceptable than policy approaches designed to promote voluntary behavioral changes or that rely on market-based solutions (de Groot and Schuitema, 2012; Howard et al., 2017; Rissman et al., 2017; Steg et al., 2006). A better understanding of why individuals support or oppose regulations on the agricultural industry will

provide insight into public support for on-farm nutrient management practices and inform related policy discussion and development.

In this study, we investigate the drivers of support for regulations to reduce nutrient pollution by testing the effects of two policy specific beliefs, political orientation, and environmental worldview with survey data from residents in Ohio, United States. We set out to advance the understanding on public support for regulations in three ways: (1) testing the effects of two novel regulation-specific beliefs, support for autonomy and support for external accountability, (2) simultaneously examining the effects of political orientation and environmental worldviews, and (3) comparing the direct and indirect effects of political orientation and environmental worldview using model selection techniques. In the next sections, we summarized relevant past studies on public acceptability of environmental regulations including the effects of political orientation and environmental worldview. We proposed two models that test the direct and indirect effects of political orientation

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and environmental worldview.

2. Literature review

2.1. Support for farmers' autonomy and external accountability

We propose that two novel policy-specific beliefs, support for *autonomy* and support for *external accountability*, play a critical role in determining individual support or opposition to a specific regulatory policy measure. Autonomy refers to farmers' ability to make decisions that they think are right for their farm, and accountability describes farmers' responsibility for their farm management outcomes. Particularly, farmers' self-regulation and intention to steward farmlands are the manifestation of farmers' autonomy in reducing nutrient runoff. The extent to which the public supports farmer autonomy may affect their support for regulation of common agricultural practices. As researchers discovered, the perception of infringements on individual freedom of choice (i.e., infringement on individual autonomy) is a key source of the unpopularity of many regulations (Eriksson et al., 2008; Jagers et al., 2018; Steg et al., 2006). In other words, if the polluters are self-motivated and able to change their actions on their own, it is more desirable to avoid regulation (Steg et al., 2006). Thus, support for autonomy is linked with decreased support for regulations. In comparison, support for external accountability is likely to increase support for regulations. As noted by Jagers et al. (2018), "examples of people voluntarily cooperating on a larger scale, involving a widely dispersed and mutually anonymous multitude of people, are strikingly rare." (p. 86) Environmental groups often advocate for regulations as means to ensure external accountability, especially when the desired behavior change may impose economic losses on the polluter or requires effort to carry out.

Nevertheless, beliefs about farmers' autonomy and external accountability have not been explicitly tested in the policy acceptability literature. In our attempt to conceptualize these two complicated concepts, we consider public support for farmers' autonomy and external accountabilities as latent constructs, which consist of specific beliefs about farmers' intention and behaviors. Specifically, the conceptualization of autonomy beliefs is informed by research on trust. Guo et al. (2019a) found that residents who trust farmers and their judgements related to water quality are less likely to support state government efforts to introduce fines on excessive agricultural runoff. Others have found that low trust in business actors explains why people in some countries demand more regulations (Aghion et al., 2010; Harring, 2018). The conceptualization of accountability beliefs is informed by policy discussion around mitigating agricultural runoff to Lake Erie (Coleman, 2016; Guo et al., 2019a).

We predict that increasing autonomy beliefs result in a decrease in support for regulations, while increasing accountability beliefs result in an increase in support for regulations.

H1. Autonomy beliefs will have a direct effect on support for regulation, with increasing strength of autonomy beliefs resulting in a decrease in support for regulations.

H2. Accountability beliefs will have a direct effect on support for regulation, with increasing strength of accountability beliefs resulting in an increase in support for regulations.

2.2. Political orientation and environmental worldview

People's attitudes towards environmental regulation are thought to be rooted in their political orientation and environmental worldviews (Dietz et al., 2007; Jagers et al., 2018; Van Boven et al., 2018). Political orientation describes a person's beliefs and opinions about characteristics of the political and economic system (political ideology) and often manifests as their affiliation with political parties (Cruz, 2017; Harring and Jagers, 2013). The most common scale to measure individual

political ideology is along the strongly liberal to strongly conservative spectrum. People who place themselves towards the 'strongly liberal' end on the scale tend to support an active, non-neutral state, a more regulated market, and universal welfare policies. Those who identify with the strongly conservative end of the scale tend to prefer a passive neutral state, an unregulated market, and limited social policy interventions (Harring and Jagers, 2013). Environmental worldviews, on the other hand, reflect beliefs about a human's relationship with the natural environment (Dunlap et al., 2000). The most widely used measure for environmental worldview is the New Environmental Paradigm (NEP), which measures individuals positions on belief statements such as "human activities impact the balance of nature," "human beings have the right to modify and control the natural environment", and "an eco-crisis is possible" (Hawcroft and Milfont, 2010). Conceptually, political orientation and environmental worldview are two related components of an individual's fundamental view of the world (Ziegler, 2017).

Overall, those who endorse a liberal political ideology, or pro-environmental worldview, tend to support more stringent regulation and 'stick'-type policies (bans, penalties), those who are more conservative politically and individualistic in their worldview favor market-based approaches and more 'carrot'-type policies (incentives and credits) (Jagers et al., 2018; Rissman et al., 2017; Attari et al., 2009; Tosun et al., 2020; Merrill and Sintov 2016; Milman et al., 2018). However, few studies of policy support have examined political orientation and environmental worldview simultaneously (Harring and Jagers, 2013; Ziegler, 2017). Those studies that have been conducted reveal somewhat mixed findings about the relative strengths of political orientation and environmental worldviews in predicting policy support. While some have found that when environmental worldview is included in the model, political orientation is no longer a significant predictor of policy support (Attari et al., 2009; Harring and Jagers, 2013; Shwom et al., 2010), others have shown both environmental worldview and political ideology as significant independent predictors (Ziegler, 2017). Our hypotheses predict environmental worldview and political ideology both directly affect support for regulations, yet we acknowledging that the literature is inconclusive on these relationships.

H3. Political orientation will have a direct effect on support for regulation, with conservative political orientation associated with decreased support for regulations.

H4. Environmental worldview will have a direct effect on support for regulations, with a stronger pro-environmental worldview associated with greater support for regulations.

Our last sets of hypotheses expect political orientation and environmental worldview affecting the autonomy beliefs and the accountability beliefs. Those who endorse a strong environmental worldview may be resistant to the idea that industrial agricultural practices can have positive environmental outcomes (Heise and Theuvsen 2016; Tosun et al., 2020), and thus be inclined to hold a low level of support for farmer autonomy but high level of support for farmer accountability. Conversely, those who self-identify as politically conservative may have a high level of support for farmer autonomy, consistent with their beliefs in free market, while having a low level of support for farmer accountability, consistent with their reservations with government intervention (Jagers et al., 2018).

H5. Political orientation will have a direct effect on policy-related beliefs, with autonomy beliefs increasing and accountability beliefs decreasing with increasingly conservative political orientation.

H6. Environmental worldview will have a direct effect on policy-related beliefs, with autonomy beliefs decreasing and accountability beliefs increasing with increasingly pro-environmental worldview.

3. Materials and methods

We tested these hypotheses through two alternative models. Our analyses are based on the data collected from an online survey of Ohio residents that was conducted in November 2018. The survey gauged public awareness of and preferences for solutions to harmful algal blooms in Lake Erie, one of the Laurentian Great Lakes. In this section, we first introduced the models and then summarized the data and analyses we used to test the models.

3.1. Models

We tested two alternative models about the effects of autonomy beliefs, accountability beliefs, political orientation, and environmental worldview on support for specific regulatory policies. The first model only includes the direct effects of the autonomy belief, accountability belief, political orientation, and environmental worldview on regulation support (Fig. 1). This model emphasizes that political orientation and environmental worldview operate independently and directly, and not through policy beliefs.

In comparison, the second model only includes the indirect effects of political orientation and environmental worldview on regulation support (Fig. 2). The model emphasizes that political orientation and environmental worldview operate through the policy-related beliefs. In other words, the autonomy belief and the accountability belief are hypothesized to fully mediate the effects of political orientation and environmental worldview on regulation support.

We propose to compare the two models statistically to test whether the two policy specific beliefs fully mediate the effects of political orientation and environmental worldview. Traditionally, researchers directly fit a partial mediation model but test the full mediation hypotheses through qualitatively assessing the significance of the direct and indirect paths. In comparison, our multiple model approach will quantify which model specification best fits the data, and by how much. Any detected difference in the model fit statistics results directly from whether political orientation and environmental worldview are specified as directly or indirectly affect regulation support. Although the multiple model approach is a standard practice in natural science fields such as ecology (Johnson and Omland, 2004), it is less common in the mechanism studies about public support for environmental policies. Due to insufficient prior evidence we do not have a hypothesis about which

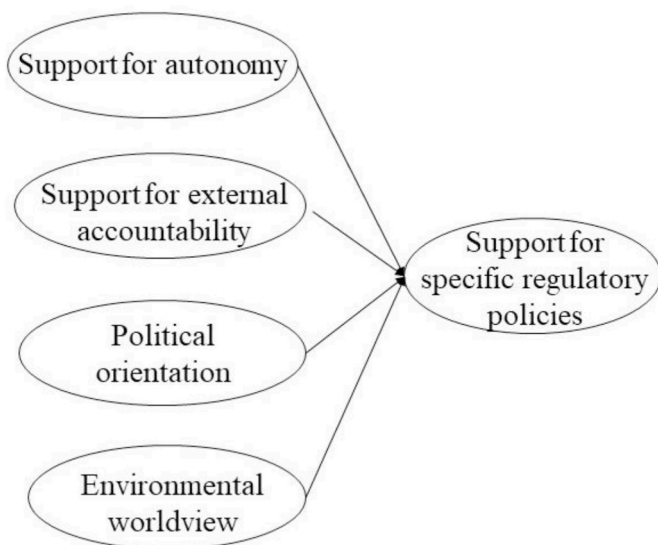


Fig. 1. Model 1 is a direct effect model describing how political orientation, environmental worldview, and policy-specific beliefs affect support for environmental policies.

model will perform better. Nevertheless, with using this “novel” approach, we attempt to expand on how pathways for public policy support can be tested.

3.2. Study case

The frequency, extent, and peak severity of toxin forming HABs in Western Lake Erie have increased since the mid-1990s (Michalak et al., 2013; Stumpf et al., 2012). Annual economic loss due to blooms in Western Lake Erie is estimated at \$65 to \$71 million (Bingham et al., 2015). In 2016, under the Great Lakes Water Quality Agreement, the U. S. and Canada Government set a target of reducing nutrient loading in Lake Erie by 40% (Maccoux et al., 2016; Scavia et al., 2016; Stumpf et al., 2016). Most of these reductions need to occur in agricultural runoff. Regulations on agricultural runoff—including fines for excessive agricultural runoff—are considered one tool that might ensure accountability but face strong opposition from the farming community (Garnache et al., 2016; Shortle et al., 2012; Guo et al., 2019b). The center of the discussion is in the Midwestern state of Ohio, a state that receives the most impacts from HABs in Lake Erie but also contributes the most agricultural nutrient loading to the Lake (Maccoux et al., 2016). In this situation, Ohio residents’ support for (or resistance to) regulations on agricultural nutrient runoff may motivate (or discourage) politicians to introduce regulatory policies to address the HAB problem in Lake Erie.

3.3. Survey implementation

We collected public opinion data through survey firm YouGov. One thousand (1000) Ohio residents enrolled in YouGov’s online panel completed the survey. These cases matched to a target sample that was drawn from a constructed sample frame using results from the American Community Survey. The matching criteria were gender, age, race and education. The sample was also set to represent the five Ohio EPA districts that are managed by the Central District Office, Northwest District Office, Southeast District Office, Northeast District Office and the Southwest District Office (<https://epa.ohio.gov/Districts>). Weights were calculated using propensity scores and were used in all descriptive and modeling analyses.

3.4. Measures

Support for regulation. We selected penalties on excessive agricultural runoff as a specific example of regulations because it is intuitive for respondents to understand without detailed explanations. Respondents were asked “If the education, technical assistance and cost-share programs reduced fertilizer runoff to Lake Erie by 5% (instead of the 40% target), how much would you support state government introduction of fines for farmers who allow too much agricultural runoff” using a seven-point scale with one (1) meaning strongly oppose and seven (7) meaning strongly support. The question set up a scenario in which voluntary policies (i.e., education, technical assistance, and cost) were not effective in reducing agricultural runoff.

Support for farmer autonomy. We used three questions to measure individual support for farmer autonomy. The first question measure respondents’ self-reported trust-level, “In general, to what extent do you trust Ohio farmers to manage the land well?”, with one (1) meaning strongly distrust and seven (7) meaning strongly trust. The other two questions are Likert Scale questions asking respondents to rate their levels of agreement with two statements “Ohio farmers are generally sensitive to the concerns of Lake Erie water quality,” and “Most Ohio farmers have been careful in applying fertilizer to their lands.” For these two questions, selecting one (1) meant strongly agree, and seven (7) indicated strongly disagree.

Support for external accountability. We asked respondents to rate their levels of agreement with three statements” With the threat of penalty,

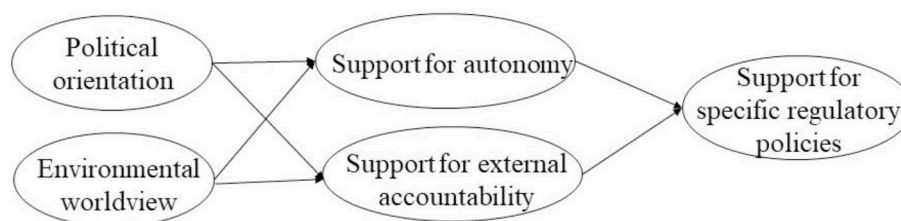


Fig. 2. Model 2 is a mediation model describing how political orientation, environmental worldview, and policy-specific beliefs affect support for environmental policies.

farmers are more likely to adopt best management practices to reduce fertilizer runoff,” “Farmers have too much freedom to do what they want on their land,” and “Regulations are necessary to keep farmers accountable for their land management practices.” For these questions, seven (7) indicated strong agreement, and one (1) indicated strong disagreement.

Political orientation. Political orientation was measured using two questions following Ziegler’s (2017) approach. For political ideology, respondents were asked: “In general, how would you describe your own political viewpoint” on a five-point scale with one (1) meaning very liberal and five (5) meaning very conservative. Respondents’ party affiliation was measured on a seven-point scale with one (1) meaning strong Democrat and seven (7) meaning strong Republican. These two items were used as the indicator for the latent variable political orientation in the SEM models.

Environmental worldview. We measured the environmental worldview using the revised 15-item NEP scale (Dunlap et al., 2000). Respondents were asked to rate their level of agreement to statements such as “The earth has plenty of natural resources if we just learn how to develop them” and “If things continue on their present course, we will soon experience a major ecological catastrophe.” Responses were selected from a seven-point scale with one (1) meaning strongly disagree and seven (7) meaning strongly agree. Eight of the items are consistent with an environment-centric worldview while the other seven items were worded to represent a human-centric worldview (Dunlap et al., 2000).

3.5. Data analysis

The hypotheses were tested with Structural Equation Modeling package LAVAAN in R ver. 3.6.3. Given the variables were measured by Likert scales, we used robust Maximum Likelihood Estimator (specifying “estimator = mlr” in R) to account for the impacts of measurement on the multi-normality assumption (Li, 2016; Rhemtulla et al., 2012). For environmental worldview, we followed Dunlap et al., (2016) scale reduction method and conducted Principal Component Analysis (PCA) with anti-NEP items reverse coded. We used the factor score of the first principle component as people’s environmental worldview scores, with higher scores indicating a stronger pro-environmental worldview.¹ To specify environmental worldview as a latent variable with a single indicator (NEP score), we set the variance of the latent variable as $(1 - \lambda)$ the variance of the single indicator, where λ is the reliability of the single item in measuring the latent variable (Petrescu, 2013). We set the λ to be a conservative value of 0.9, informed by the reliability of the NEP scale (Cronbach’s $\alpha = 0.90$). The value of λ is lower than the value of 0.95

¹ There is an ongoing debate about the latent factor structure of the NEP scale. Some researchers used a single NEP scale score while others argued for three-factor, four-factor, and even five-factor structure (Hawcraft and Milfont, 2010; Amburgey and Thoman, 2012; Xiao and Buhmann, 2017). We tested a five-factor structure and a second-order factor structure of NEP, but neither measurement model fit the data. Instead, we followed Dunlap’s suggestion (Dunlap et al., 2000), and used NEP score as a single indicator for the latent variable of environmental worldview.

suggested by Anderson and Gerbing (1988) when the estimate for the error variance of the single indicator is absent. We used five goodness of fit criteria, including p-value of chi-square >0.05 , CFI >0.9 , TLI >0.9 , RMSEA <0.06 , SRMR <0.05 (Bentler, 1990; Hu and Bentler, 1999). Cases with missing values were deleted from the analyses. We compared the Direct Effect Model and the Mediation Model using likelihood ratio test, Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). The models with smaller AIC and BIC indicate a better fit to the data.

4. Results

The survey collected 1000 completed surveys. Some of the survey had missing answers for select questions. After using listwise deletion, the resulting sample size for model testing was 729. In the following sections, we first describe the sample, after which we summarize the modeling results.

4.1. Respondents profile

The weighted sample descriptions were as follows: 52.8% female, 82.2% white alone, 11.8% African American, 93.1% 25 years old and over, among whom 27.5% has bachelor’s degree or higher. Geospatially, 14.8% of the sample was from Northwest Ohio, 32.8% from Northeast Ohio, 24.5% from Southwest Ohio, 18.1% from Central Ohio, and 9.8% from Southeast Ohio. In the sample, 9.7% respondents work or have previously worked in the agricultural industry. It is considerably higher than the estimated number of employments per 1000 jobs in Ohio for combined farming, fishing and forestry occupations (0.935, equivalent to 0.09%) (U.S. Bureau of Labor Statistics, 2018). Less than ten percent respondents (6.0%) work or previously worked on or near Lake Erie in industries such as fishing industry, tourism, recreation, and shipping. About a third of respondents (33.9%) used Lake Erie for recreational purposes. On average, respondents rated their knowledge of farming in Ohio as less than intermediate but more than novice (mean = 2.9, S.D. = 1.5, on a seven-point scale).

When voluntary programs were projected to achieve a nutrient loading reduction of 5%, respondents, on average, somewhat supported the state government to introduce fines on excessive agricultural runoff (Table 1).

The explanatory factor analysis for the six items of autonomy belief and accountability belief suggested two latent factors with eigenvalues larger than one and the item-loading pattern was as expected. We then calculated the mean of each scale as a proxy for the belief score. The correlation between the two belief scores was significant but weak ($r = -0.21$, p-value $<.0001$), suggesting the two beliefs were distinct constructs (More details on the relationship between the two beliefs are in the supplementary materials).

Both political ideology and Party ID significantly correlated with individual support for fines on excessive agricultural runoff. Residents who held more conservative ideology ($r = -0.31$, p-value $<.0001$) or identified with the Republican Party more strongly ($r = -0.20$, p-value $<.0001$) were less likely to support fines, even under the scenario that voluntary nutrient reduction programs were deemed ineffective.

Table 1
Mean and Standard deviation of items measuring fine support, autonomy beliefs, accountability belief, environmental worldview, and political orientation.

Items	N	Mean	S.D. *
Support for fines on excessive agricultural runoff	1000	4.7	1.7
<i>Autonomy belief</i>			
Auto1: General level of trust in Ohio farmers to manage the land well	1000	4.6	1.4
Auto2: Ohio farmers are generally sensitive to the concerns of Lake Erie water quality	884	4.3	1.4
Auto3: Most Ohio farmers have been careful in applying fertilizer to their lands	860	4.3	1.5
<i>Accountability belief</i>			
Acco1: With the threat of penalty, farmers are more likely to adopt best management practices to reduce fertilizer runoff	936	5.0	1.4
Acco2: Farmers have too much freedom to do what they want on their land	893	3.6	1.6
Acco3: Regulations are necessary to keep farmers accountable for their land management practices	947	5.1	1.5
<i>Environmental worldview – NEP score</i>	998	4.7	1.0
<i>Political orientation</i>			
Ideology	927	3.2	1.2
Party ID	973	3.8	2.2

*S.D. Standard Deviation.

Note. The beliefs items using a seven-point scale, with one indicating strongly disagree, and seven indicating strongly agree.

Similarly, respondents who held stronger pro-environmental worldview showed stronger support for fines on excessive agricultural runoff when voluntary programs were deemed ineffective ($r = -.46$, $p < .0001$).

4.2. Modeling results

The initial measurement model consisted of political worldview, environmental worldview, autonomy beliefs, and accountability beliefs revealed acceptable values of CFI (0.960), TLI (0.941), RMSEA (0.070), and SRMR (0.056), but the chi-square was significant (Chi-square = 130.013, $df = 45$, $p < .001$), indicating poor model fit to the data. Therefore, we used the Modification Index (MI) to improve model fit. MI calculated by the LAVAAN package in R suggested five changes, including adding correlated errors between three pairs of items, and adding two items to additional latent variables (For details of measurement model re-specification see Supplementary materials). The re-specified measurement model was a significant fit to the data (Chi-square = 21.62, $df = 17$, $p < .2$).

Using the re-specified measurement model, Model 1 (the Direct Effect Model) fit the data well (Robust Chi-square = 28.837, $df = 22$, $p < .150$, Robust CFI=.996, Robust TLI=.991, Robust RMSEA=.028, SRMR=.030, Table 2). It explained 44.9% of the variance in support for fines. Model 2 (the Mediation Model) also fit the data (Robust Chi-square = 30.086, $df = 25$, $p < .221$, Robust CFI=.997, Robust TLI=.994, Robust RMSEA=.023, SRMR=.030). It explained 44.5% of the variance in support for fines.

In Model 1, autonomy belief (Standardized $\beta = -.20$, $p < .001$) and accountability beliefs (Standardized $\beta = .62$, $p < .001$) significantly predicted individual support for fines, supporting H1 and H2 (Fig. 3). Conversely, political orientation (Standardized $\beta = -0.05$, $p < .377$) and environmental worldview (Standardized $\beta = -.08$, $p < .384$) did not directly predict support for fines, rejecting H3 and H4.

Table 2
Model fit results.

Model	Chi-square	df	p-value	Robust CFI	Robust TLI	Robust RMSEA	SRMR	AIC	BIC
Model 1: Direct Effect	28.837	22	.150	.996	.991	.028	.030	23387	23538
Model 2: Mediation	30.086	25	.221	.997	.994	.023	.030	23386	23523

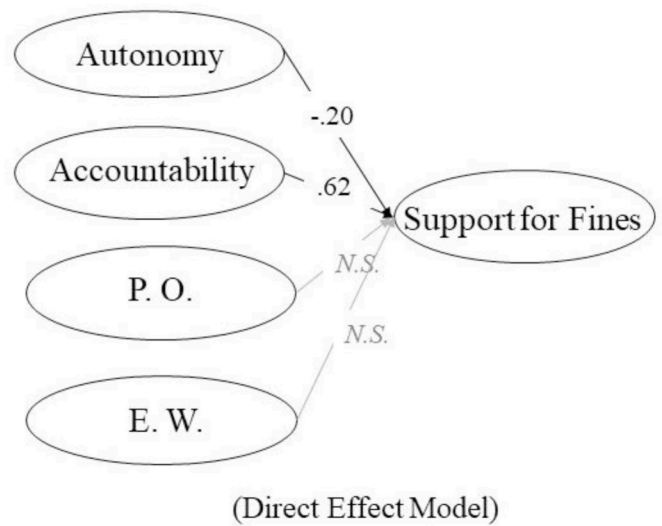


Fig. 3. Model 1: standardized coefficients of the significant paths in the direct effect model.

In Model 2, autonomy beliefs (Standardized $\beta = -.17$, $p < .002$) and accountability beliefs (Standardized $\beta = .59$, $p < .001$) remained significant predictors of individual support for fines, supporting H1 and H2 (Fig. 4). Environmental worldviews significantly predicted the autonomy beliefs (Standardized $\beta = -.42$, $p < .001$) and the accountability beliefs (Standardized $\beta = .68$, $p < .001$). As we hypothesized, individuals who hold stronger pro-environmental worldview were more likely to support external accountability, while less likely to trust the autonomy of farmers in reducing nutrient runoff (supporting H6). However, different from our expectation, political orientation did not significantly predict autonomy belief (Standardized $\beta = .07$, $p < .342$) or accountability belief (Standardized $\beta = -.06$, $p < .439$) (rejecting H5).

When comparing the two models, the likelihood ratio test suggested no significant difference between the two models (Chi-square difference = 1.817, Degree of Freedom difference = 3, $p < .6113$). The AIC and BIC of the models were also similar, suggesting neither the Direct Effect model nor the Mediation Model fit the data better (For extended modelling efforts, including the test on a partially mediated model, please see Supplementary Materials).

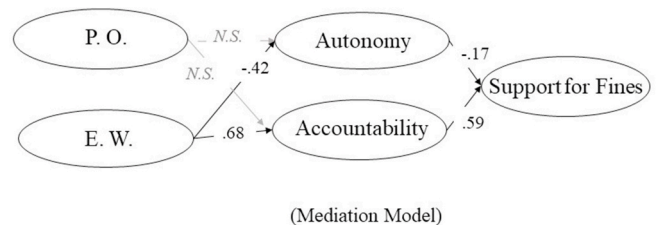


Fig. 4. Model 2: standardized coefficients of the significant paths in the mediation model.

5. Discussion

In this paper, we used survey data from Ohio residents to analyze how autonomy beliefs, accountability beliefs, political orientation and environmental worldview influence individual support for specific regulatory policies to reduce agricultural nutrient runoff. We fitted a direct effect model (Model 1) and a mediation model (Model 2), with the two beliefs fully mediating the effects of political orientation and environmental worldview on support for regulations. The results supported the direct effects of autonomy beliefs and accountability beliefs on support for fines but did not support the direct effect of political orientation or environmental worldview. Environmental worldview had an indirect effect on support for fines for excessive agricultural runoff through autonomy and accountability beliefs. There were no significant indirect effects of political orientation.

As hypothesized, autonomy beliefs and accountability beliefs appear to play a significant role in determining individual support for specific regulations. Our measurement of autonomy beliefs reflects trust in the agriculture industry (Guo et al., 2019a), and results are consistent with other studies showing that trust in the targets of regulation (in this case, agricultural producers) decreases individual support for environmental regulations (Aghion et al., 2010; Harring, 2018). The modelling results also suggest accountability beliefs play a larger role in determining support for regulations than the effects of autonomy belief. In other words, a key driver for public support of environmental regulations may be a desire for external accountability. This finding follows similar conclusions from Tosun et al. (2020), who documented growing public awareness of aquatic pollution, an ascription of responsibility to agriculture and industry actors, and increased support for strong top-down regulation of these sectors.

When comparing the effects of political orientation and environmental worldview, neither directly predicted individual support for fines on excessive agricultural runoff. However, environmental worldview showed indirect effects on support for fines through autonomy beliefs and accountability beliefs. As predicted, people who held a strong pro-environmental worldview showed high levels of support for external accountability but low levels of support for farmer autonomy. These results are consistent with biased information processing and motivated reasoning (Hart et al., 2015). Environmental worldview may affect how people view the intentions and willingness of agricultural producers to solve the HABs problem. The different views on farmers then played a critical role in individual attitude formation toward stringent regulatory policy.

We found that there were no direct or indirect effects of political orientation on support for fines. Our results add to the mixed findings from other studies that have simultaneously tested the effects of environmental worldview and political orientation (Attari et al., 2009; Harring and Jagers, 2013; Ziegler, 2017). The results from our study suggest that environmental worldview may be a more salient factor in the formation of autonomy beliefs, accountability beliefs, and support for fines, as compared to political orientation. One speculation for this difference was that the HABs issue in Lake Erie was not as politically polarized as other environmental issues like climate change. People's policy preference for HABs may instead be more in tune with their views on human's relationship with the natural environment, and their observations of the potential vulnerability of Lake Erie to human stressors. Another possibility is that political orientation and environmental worldview measured by NEP are highly correlated, and thus political orientation did not make a significant independent contribution to the explanatory power of the model. In addition, conservative political orientation might decrease support for regulations through other mediators such as decreasing news exposure and risk perceptions (Guo et al., 2019b). Political orientation may moderate the effects of environmental worldview on autonomy beliefs and accountability beliefs. These alternative explanations of the lack of effects of political orientation are worth investigating in future research.

Lastly, although autonomy and accountability beliefs fully mediated the effects of environmental worldview on support for regulations, the model-comparison methods were inconclusive. Overall, the strengths of this study include a representative sample with 729 cases and a rigorous modelling approach. We were able to achieve our first and second contributions, but left questions for future studies to discern the specific nature of the effects of political ideology and environmental worldview on environmental policy.

5.1. Limitation and future research

The study has limitations that are worth acknowledging. First, we used cross-sectional data and Structural Equation Modeling to infer the causal effects of political orientation, environmental worldviews, autonomy beliefs, and accountability beliefs, on support for fines. Although our results revealed strong signals for some of the effects, confirming causality requires longitudinal studies or controlled experiments with interventions (Dunning 2008). Second, there may be additional variables which play a role in mediating the effects of political orientation on support for fines, and which were not included in this study, such as perceived efficacy of the fine and risk perceptions (Hart et al., 2011). Third, as with other studies that used the NEP scale to measure environmental worldviews, we encountered difficulty in discerning the factor structure of the scale. In this study, environmental worldview was aggregated into a single measure and thus it was not possible to parse out which specific aspects of environmental worldview might determine a person's views on autonomy, accountability, and support for fines.

Lastly, our measurements for autonomy beliefs and accountability beliefs have not been tested in previous studies. The validity and reliability of the measurement requires further tests. We acknowledge that the latent construct approach may appear less intuitive than a single item approach (e.g., "Farmers should be able to make the decisions they think are right for their farm"), but we believe it adds useful details about public beliefs related to farmer autonomy which can inform more effective policy-related messaging. In spite of these limitations, the study provides insight into the role of autonomy beliefs, accountability beliefs, political orientation, and environmental worldview in support or opposition for specific environmental regulations.

Looking to future research, we believe it would be beneficial to continue this line of work on environmental regulations through comparing the Direct Effect Model and Mediation Model with additional fundamental beliefs and goals such as environmental values (de Groot and Steg, 2007) and cultural worldviews (Rissman et al., 2017). This would allow for integration of research on different dispositional factors (e.g., environmental values, cultural worldviews, religious beliefs) and how they affect the tending to and processing information and formation of environmental attitudes. In a separate line of economic research, studies have shown that the costs, benefits, and perceived efficacy of a policy affect individual policy preferences (Howard et al., 2017). One can argue the autonomy beliefs and accountability beliefs are closely correlated with the effectiveness of regulatory policies, or even tapping into the same construct. Comparing the relative strengths of different policy specific beliefs and specifying the conditions under which individual policy specific beliefs may play a larger or smaller role can shed more light on the dynamic and nuanced process of policy attitudes formation.

5.2. Implications for policymakers and practitioners

Overall, this study demonstrates the importance of autonomy and accountability beliefs in the public support for regulatory policies. For the study site of Lake Erie, our results revealed moderate support for fines on excessive agricultural runoff to curb HABs. We suspect such moderate level of support will not be sufficient to motivate policy makers to push a proposal for fines given the political costs and existing

oppositions. Other regulatory policies, such as mandated nutrient management planning and soil testing, should be assessed in terms of its public acceptability. When such suitable regulations are identified, our results have implications for how to improve the acceptability of specific measures. Policy makers and interest groups should take into account public trust in the agricultural industry, meaning perceptions of how likely farmers will adopt conservation practices without external requirements. Further, policy makers and interest groups should partner with natural and social scientists and provide best available information on agriculture industry's self-regulation measures and historical adoption rates for conservation practices. Projections about adoption rates with or without the proposed regulation can also help the public calibrate their trust or distrust in the agricultural industry. Coupled ecological and social studies are needed to assess the likelihood of the agricultural industry voluntarily adopting conservation practices and forecasting the effectiveness of potential accountability measures in reducing nutrient runoff, such as mandated nutrient management plan and soil testing.

It is worth recognizing that presented with similar information, individuals may form different autonomy and accountability beliefs because of differences in environmental worldview. During policy development and implementation stages, policy makers should give greater consideration to biased information processing and motivated reasoning among the public. Individuals with stronger pro-environmental worldview are most predisposed to support environmental regulations, and thus may be more attentive and receptive to evidence that reinforces these policy preferences. Identifying such differences in Ohio residents is important, policy agencies need to craft tailored outreach messages that will resonate individuals with different environmental worldviews (Hart et al., 2011). These suggestions may apply to other regions that have problem with agricultural nutrient runoff and see increasing public polarization along political ideology and environmental worldview.

6. Conclusion

The goal of the study was to examine drivers of support for regulations in the context of agricultural nutrient runoff in Ohio and HABs in Lake Erie. We found belief about farmer autonomy and belief about external accountability significantly predicted individual support for regulations on agricultural runoff. Both beliefs were rooted in individual environmental worldview but not in their political ideology. When tested simultaneously, environmental worldview showed stronger effects on support for regulations than political orientation. We believe that improvements in Lake Erie water quality (including reductions in the frequency and intensity of HABs) can be achieved—in part—by building support for regulatory policies across a broad spectrum of the Ohio public and by tailoring related communication and outreach to the diversity of policy-specific beliefs and environmental worldviews that underlie this support.

Credit author statement

Tian Guo: Conceptualization, Methodology, Software, Formal analysis, Writing – original draft; Victoria Campbell-Arvai: Conceptualization, Methodology, Writing – review & editing; Bradley Cardinale: Conceptualization, Resources, Writing- Review and Editing, Supervision, Funding acquisition

Declaration of competing interest

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

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jenvman.2020.111708>.

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