

Public attitudes toward biofuels

Effects of knowledge, political partisanship, and media use

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ABSTRACT. Despite large-scale investments and government mandates to expand biofuels development and infrastructure in the United States, little is known about how the public conceives of this alternative fuel technology. This study examines public opinion of biofuels by focusing on citizen knowledge and the motivated processing of media information. Specifically, we explore the direct effects of biofuels knowledge and the moderating effect of partisanship on the relationship between media use and benefit vs. risk perceptions in the following four domains: environmental impacts, economic consequences, ethical/social implications, and political ramifications. Our results suggest that more knowledgeable respondents see fewer benefits of biofuels relative to risks, and that Democrats and Republicans are affected differently by media use when forming opinions about biofuels. Among Democrats, greater attention to political media content leads to a more favorable outlook toward the technology across several domains of interest, while among Republicans, an increase in attention to political content has the opposite effect. Possible reasons for these results, as well as implications of the findings at the intersection of politics and the life sciences, are discussed.

Key words: Biofuels, public opinion, risk perceptions, motivated reasoning, science knowledge, partisanship

In recent years, due in large part to the instability of oil prices and a desire to lessen dependence on foreign oil, the United States government has made development of renewable energies a top priority. As part of this commitment, the U.S. has mandated biofuels production and made hundreds of millions of

dollars in investments in the fledgling industry.¹ However, government mandates and increased funding do not necessarily mean a technology will live up to its potential. Possible alternative energy solutions, such as biofuels, may only be useful to the extent that the public is willing to support their use and development.² As the controversy in Europe over genetically modified foods has demonstrated, a lack of public support, due

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in large part to fluctuations in risk and benefit perceptions, can lead to rejection of emerging technologies and scientific innovation.^{3,4,5,6,7} An understanding of how the public evaluates risks and benefits for emerging innovations such as biofuels is therefore crucial for policymakers and industry leaders alike in order to determine the future of scientific energy innovation. Moreover, such an understanding can aid in creating a dialogue between the general public and those in the scientific community by suggesting strategies for effective communication.

To build such understanding, this paper focuses on how citizens use knowledge and selectively process media information when forming opinions about emerging science and technology. First, we examine the main effects of knowledge, news media attention and political party affiliation on benefit versus risk perceptions in four domains where biofuels are relevant: environmental impacts, economic consequences, ethical/social implications, and political ramifications. Second, we examine how political orientation interacts with media use to garner a more detailed understanding of how attention to news media shapes perceptions of biofuels benefits relative to risks. In doing so, the current study traces a theoretical and empirical path bridging the literature in political and science communication. Before outlining this approach in greater detail, however, we first situate our study within the controversy surrounding biofuels.

The debate over biofuels

As noted, the U.S. government is in the midst of heavy investment in biofuels with the hope that the alternative fuel can become a major source of energy in the coming years. The term “biofuels” refers to any energy source made from renewable organic matter, including wood and other forest products, plants, human and animal waste, and agricultural crops.⁸ However, the term has emerged most prominently within public discourse over fuels used for transportation, such as ethanol and biodiesel. In the U.S., these biofuels are commonly combined with petroleum-based fuels to make blends like E10 (10 percent ethanol and 90 percent gasoline), or E85, an 85 percent ethanol blend used in specially manufactured vehicles.⁹

Despite these government investments, or perhaps because of them, controversy surrounds the industry. On the one hand, a number of organizations have embraced biofuels. Several airlines have begun testing biofuel blends in their jet fuel in an attempt to lessen costs and cut down on greenhouse gas emissions.¹⁰ The U.S. military is currently testing biofuel blends with the goals of increasing fuel security, reducing fuel costs, and reducing negative environmental impacts.¹¹ On the other hand, there are a number of opponents to biofuels who have been highly critical of the energy source. Jean Ziegler, United Nations Special Rapporteur on the right to food, called it a “crime against humanity to divert arable land to the production of crops which are then burned for fuel.”¹² Similar sentiments have been expressed by Jeffrey Sachs, former Director of the United Nation’s Millennium Project and co-founder of the Millennium Promise Alliance, a nonprofit organization dedicated to ending extreme poverty and hunger. Sachs has been highly critical of biofuels as “putting food in our gas tanks.”¹³ Still others have questioned the environmental friendliness of biofuels, noting that some scientific evidence points to biofuels having negative environmental consequences once indirect land use impacts are taken into account.¹⁴

Biofuels: Exploring public perceptions

Despite this controversy, there is very little published work specifically exploring public opinion of biofuels.^{15,16} A survey conducted in 2008 found that 67 percent of U.S. respondents were interested in learning more about the alternative fuel.¹⁷ The same survey also probed respondents benefit and risk perceptions about the fuel. A majority of those surveyed agreed that biofuels can help reduce U.S. dependence on foreign oil while cutting down on greenhouse gas emissions. However, not all the findings indicated clear positive attitudes toward this alternative energy source. Respondents also expressed some reservations about corn-based ethanol, with 44 percent voicing concerns that ethanol production will create pressure on the food supply, and a similar percentage (43 percent) fearing it will put pressure on local water supplies. More generally, barely a quarter of those surveyed agreed that biofuels can be a permanent solution to the energy problems in the U.S.¹⁷

In a study of individual-level predictors of attitudes toward biofuels, Wegener and Kelly found largely positive evaluations of biofuels in the U.S., particularly when compared to more traditional forms of energy (e.g., coal-based and oil-based sources).² However, the authors also noted that these opinions are not especially strong and that the public readily admits to being uninformed about the alternative energy source, especially sources that are not corn based. Similarly low levels of biofuels awareness among Americans have been reported by Adelle and Withana, who note that very few U.S. survey respondents report familiarity with bioenergy or biomass.¹⁸ This lack of awareness is not unique to the United States, as a number of European studies have noted parallel trends in public information about bioenergy.^{19,20} Importantly, these studies do not necessarily suggest a public that has failed to *embrace* biofuels; rather, they suggest a public that is largely *uninformed* about the renewable fuel. More importantly, they suggest that the current opinions are highly malleable and may be susceptible to change based on several factors, including shifts in knowledge levels, changes in media use patterns, and reliance on decisional heuristics.

Knowledge and attitudes toward science

The impact of knowledge on science attitudes has been much debated during the past two decades. Early work focused largely on a knowledge deficit approach, which suggested that there was a direct relationship between low levels of public science knowledge and low levels of scientific support.^{21,22} A knowledge deficit approach assumes a public that is both willing and able to seek out the necessary information about science topics in order to arrive at informed and accurate opinions.^{23,24} This approach argues that simply providing more information will make the public better informed about science and more supportive of scientific developments generally.^{23,24} And, indeed, some research has found strong positive relationships between public knowledge levels and support for a number of scientific issues.^{25,22,26} Moreover, some have speculated that low levels of support for biofuels in Europe can be explained by the accompanying low levels of knowledge about alternative energy sources.²⁷

However, support for the deficit model is uneven with some studies finding no relationship between

knowledge levels and scientific attitudes,^{28,29,30} and others finding the relationship to be contingent on additional factors.^{31,32} Given the ambiguity concerning the relationship between science knowledge and attitudes, we propose the following research question about knowledge levels and public attitudes:

RQ1: What impact will biofuels knowledge have on perceptions of net benefits and risks of biofuels across our four domains of interest: the environment, the economy, politics, and ethics?

Motivated reasoning and information management

While knowledge levels have been a central focus of much research on scientific attitude formation, some scholars have moved away from a knowledge deficit model, arguing that the model is overly simplistic.^{33,34} Instead, these researchers argue, citizens can be more accurately described as “satisficers” or “cognitive misers” who strive to minimize their information-seeking efforts and, therefore, rely more heavily on cognitive heuristics when forming opinions about science and technology issues.³⁵ The importance of political ideology in influencing science attitudes, for example, has been demonstrated across a number of issues. Conservatives tend to be less supportive when it comes to nanotechnology,³⁵ stem cell research,^{32,36} and agricultural biotechnology,^{37,38} while typically perceiving fewer risks from nuclear energy.³⁹ Jenkins-Smith and colleagues argue that many questions about science are ultimately political issues, which helps explain why ideology is often so important in shaping attitudes about new technology.³⁹

Citizens rely on their ideological beliefs as heuristic cues when coming across debates in the political arena; as a result, certain subgroups can be highly susceptible to persuasive appeals by political elites.⁴⁰ In the energy debate, evidence in line with this approach is more anecdotal. For example, comments by those holding political office at the time of this data collection suggest that political elites in both parties viewed biofuels in very similar terms, namely, as a means of diversifying U.S. energy sources while moving away from dependence on foreign oil.^{41,42,43,44,45} The convergence of views on both sides of the aisle suggest that if citizens are merely following party lines in forming opinions about biofuels, there is potential for much agreement

between Democrats and Republicans. Unfortunately, there is a paucity of research addressing the impact of partisanship on attitudes toward biofuels. If individuals rely on their own political belief structure to form judgments, then we would expect a partisan divide on the issue of biofuels similar to that of other science issues. Conversely, if citizens form opinions in line with those of political elites then we would expect consensus on this issue across partisan groups. Due to the lack of research in this area, we propose the following research question regarding the influence of partisanship on benefit and risk perceptions of biofuels:

RQ2: What impact will political partisanship have on perceptions of net benefits and risks of biofuels across our four domains of interest?

Importantly, our focus on partisanship for the present study goes beyond mere ideological cues and is instead rooted in the literature on motivated reasoning—a concept that helps explain how individuals organize and process information when forming opinions. Kunda defines motivated reasoning as “reliance on a biased set of cognitive processes [or] strategies for accessing, constructing, and evaluating beliefs (p. 480).”⁴⁶ Motivated reasoning can be thought of as an umbrella term encompassing a number of cognitive processing strategies, including but not limited to disconfirmation bias, attitude congruency bias, and perceptual filters.^{31,47} Motivated reasoning is said to occur for two specific reasons. First, people are motivated by a desire to arrive at accurate conclusions when processing information and forming opinions (labeled “accuracy goals”⁴⁸). Kunda argues that accuracy goals motivate individuals to use beliefs and information processing strategies that are considered most appropriate for arriving at a careful, accurate and informed decision about a given issue.⁴⁶ Second, people are motivated to arrive at specific and directional conclusions based on prior beliefs or experiences (labeled as “partisan goals”⁴⁸). In this case, partisan or directional goals serve as a motivation for individuals to use information processing strategies that are most likely to yield desired results or conclusions.⁴⁶ This partisan or directional motivation is of particular interest for the present study.

Partisan motivations can be traced at least as far back to work by Festinger. Festinger’s cognitive dissonance theory argues that people strive for

consistency between their attitudes and behaviors, and that this desire for consistency helps explain how new information is integrated into existing knowledge structures.⁴⁹ When individuals encounter information that runs counter to existing attitudes or behaviors, cognitive dissonance occurs. Those experiencing dissonance may respond in a number of ways to minimize inconsistency. First, individuals can change their original attitude to better fit with the new information.^{49,50} Second, they can discount or disparage the dissonant information.^{49,51} Third, they can add consonant information that reduces the weight or impact of the dissonant information.^{49,50} Those engaging in the latter two strategies can be thought of as engaging in the motivated processing of information.

Support for motivated reasoning is widespread.^{25,31,47,48,52,53} For the issue of nanotechnology, Brossard and colleagues have found that knowledge tends to be interpreted through the lens of religious beliefs.³¹ That is, the link between knowledge about nanotechnology and larger evaluations of support for the science is dependent upon one’s level of religiosity. While an increase in knowledge among less religious individuals translates into greater levels of support for nanotechnology, increased knowledge among highly religious individuals does little to increase support. The authors speculate that the strong belief system of highly religious people can serve as an interpretive tool to suppress the otherwise positive effects of knowledge on nanotechnology attitudes.³¹

Analogous results have been reported by Kahan and colleagues concerning the “cultural cognition” hypothesis.^{54,55} These authors argue that individuals selectively expose themselves to information in a biased fashion reflective of their predispositions and world-views. Moreover, how individuals process information that runs counter to these predispositions is biased as well, with such information typically discounted or given less weight.^{54,55} Over time, this can result in attitude polarization among groups with opposing predispositional outlooks.

Arguably, the most complete literature on motivated reasoning is focused on political issues and the information processing strategies employed by partisan groups. Taber and Lodge, for example, examined politically charged issues (gun control and affirmative action) and found strong evidence for motivated reasoning among partisan individuals.⁴⁸ They found

that partisans evaluated attitudinally congruent arguments as stronger than attitudinally incongruent arguments, and tended to uncritically accept arguments in support of their position while extensively counterarguing unsupportive arguments. When given the choice, partisans also sought out information that confirmed their initially held positions. Such biases can lead to attitude polarization, particularly among those with the strongest initial attitudes.⁴⁸ Taber, Cann, and Kucsova later replicated these findings across a number of issues of both national and local importance.⁴⁷ Similar instances of motivated reasoning among partisan political groups have been noted for a variety of political judgments.^{56,57,58,59}

The motivated processing of media information

Communication research has convincingly established that the mass media operate as the primary source of science and technology information for the U.S. public.^{60,61,62,63} Studies have also shown that media coverage plays a key role in determining perceptions of risks, benefits and attitudes toward emerging technologies.^{26,64,65,66,67,68} Unfortunately, to date, there has been empirical work we are aware of that systematically analyzes either the impact of media use on attitudes toward biofuels or the content of media coverage surrounding the biofuels debate in the U.S. or elsewhere. The motivated reasoning literature suggests that complete knowledge of the media environment as it relates to biofuels may not be necessary to make predictions about how media content will be interpreted by citizens. Motivated reasoning suggests a number of different ways in which publics will consume media information.

First, selective exposure theory predicts that political ideology will play a key role in determining news sources that citizens use.⁶⁹ Given differences in the content and emphasis of news outlets with a partisan bent, it would not be surprising if viewers of these different sources were met with decidedly different information about the risks and benefits of biofuels. For example, former Fox News personality Glenn Beck has called biofuels “the biggest scam in the world,”⁷⁰ suggesting the type of biofuels information viewers of Fox News may be exposed to. Second, as noted earlier, previous research has found that value predispositions act as perceptual filters through which media content and other information is evaluated when forming

opinions.^{31,32,71} This suggests that media influences on perceptions of the benefits and risks of biofuels are likely to differ based on the political orientation of respondents. With this in mind, we propose the following set of hypotheses:

H1: Political party identification will moderate the role of (a) political newspaper use and (b) political television use on perceptions of net benefits of biofuels across our four domains of interest.

H2: Political party identification will moderate the role of (a) science newspaper use (both print and online) and (b) science television use (both print and online) on perceptions of net benefits of biofuels across our four domains of interest.

Method

To investigate these hypotheses and research questions, we relied on data from a statewide random-digital telephone survey of 593 adults aged 18 years and older. The data was collected in Wisconsin, a Midwest farming state and major producer of biofuels. Respondents were randomly chosen within households with working landline telephone numbers and were interviewed between April and June 2009. During this time period, the University of Wisconsin Survey Center made 12,404 phone calls to 2,258 telephone numbers. The response rate for this survey was 38.8 percent, as calculated using AAPOR’s formula for RR3.⁷²

Measures

Age, gender, and education served as control variables. *Age* was measured as a continuous variable ($M = 57.4$, $SD = 16.2$). *Gender* was a dichotomous variable with female coded as “0” and male coded as “1” (42.3 percent males). *Education* was an ordinal variable measured with eight categories. The categories ranged from “never attended school or only attended kindergarten” (coded as “1”) to “graduate degree” (coded as “8”). The sample median was “5,” indicating “college one year to three years (some college or technical school)” ($SD = 1.3$).

Partisanship was measured using seven categories that ranged from “strong Republican” (coded as “1”) to “strong Democrat” (coded as “7”). The sample had a median value of “4,” indicating “Independent” or non-partisan ($M = 4.2$, $SD = 2.1$).

Attitudes toward biofuels

Media attention was made up of four different variables designed to tap attention across two different media platforms and forms of content: political coverage on television and in newspapers online and in print and science coverage on television and in online and print newspapers. (Unfortunately, our dataset did not include equivalent measures of online political and science news attention, and therefore, such measures are excluded from the analysis.)

Attention to politics in newspapers was measured using an 11-point scale (0 = “Do not read newspapers,” 1 = “No attention at all,” 10 = “Very close attention”) asking respondents how much attention they pay to the following types of stories when reading a newspaper either in print or online: “National government and politics” and “Local affairs and politics.” The two items were averaged together to form an index with scores ranging from 0 to 10 ($M = 5.8$, $SD = 3.1$, $r = .81$).

Similarly, *Attention to science in newspapers* was measured using the same 11-point scale (0 = “Do not read newspapers,” 1 = “No attention at all,” 10 = “Very close attention”) asking respondents how much attention they pay to the following types of stories when reading a newspaper either in print or online: “Science and technology” and “Alternative energy.” Once again, the two items were averaged into a single index with scores ranging from 0 to 10 ($M = 5.0$, $SD = 2.9$, $r = .77$).

Attention to politics on television was measured using an 11-point scale (0 = “Never watch TV or TV news,” 1 = “No attention at all,” 10 = “Very close attention”) asking respondents how much attention they pay to the following topics when they watch television news: “National government and politics” and “Local affairs and politics.” The two items were averaged to form an index with scores ranging from 0 to 10 ($M = 6.6$, $SD = 2.7$, $r = .70$).

Attention to science on television was measured using an 11-point scale (0 = “Never watch TV or TV news,” 1 = “No attention at all,” 10 = “Very close attention”) asking respondents how much attention they pay to the following topics when they watch television news: “Science and technology” and “Alternative energy.” Once again, the two items were averaged into a single index with scores ranging from 0 to 10 ($M = 5.8$, $SD = 2.7$, $r = .76$).

Biofuels knowledge was measured by calculating the number of correct responses to the following nine true-false items (recoded where appropriate so that “1” = true and “0” = false across all): (a) “Last year, Wisconsin biofuels producers used about half of the state’s corn yield;” (b) “Using biofuels in cars does not create air pollution;” (c) “Biofuels can only be produced from food crops;” (d) “Fossil fuels account for more than 95 percent of energy consumed in the United States each year;” (e) “More than half of the biofuels produced in Wisconsin are being exported to other states;” (f) “More than 80 percent of the gasoline used in Wisconsin already contains ethanol additives;” (g) “Wisconsin is one of the top five producers of biofuels in the United States;” (h) “According to U.S. government estimates, ethanol can only replace one third of our current gasoline consumption;” and (i) “Government subsidies for the blending of ethanol and gasoline mostly go to oil companies.” The resulting score ranged from 0 to 9 ($M = 5.0$, $SD = 1.6$).

The dependent variables of interest for this study were measures of *net* benefit perceptions (i.e., risk perceptions subtracted from benefit perceptions) for biofuels as they pertain to the following four domains: the environment, the economy, politics, and ethics. Our decision to explore net benefit perceptions stems from work in risk analysis that recommends exploring such risk-benefit tradeoffs as a means of better informing decision makers.^{73,74} Our four domains of interest were selected on the basis of how well they represented the issues typically brought up during debates over biofuels implementation in the U.S. (for an overview of the biofuels debate, see Bringezu et al.⁷⁵), and during science debates more broadly.

Our four dependent variables were created by first averaging responses to two domain-specific risk perception measures and then subtracting that value from responses to two domain-specific benefit perception measures. This operationalization follows from recent work highlighting the low reliability associated with asking respondents to report a global evaluation with a single survey question.⁷⁶

The combination of measures left us with an overall benefit vs. risk perception measure for each of our four domains. Thus, we created our *Net environmental benefits* measure by asking respondents their level of agreement with the following two environmental risk

perception statements: “Biofuels will have negative environmental impacts,” and “Biofuels production will threaten plants and wildlife.” These two items, assessed using 10-point scales where 1 = “Strongly disagree” and 10 = “Strongly agree,” were averaged together ($M = 4.4$, $SD = 2.0$, $r = .36$) to create a measure of environmental risk perceptions. Next, we averaged responses to the following two environmental benefit perception statements: “Biofuels are less damaging to the environment than petroleum-based fuels” and “Biofuels burn cleaner than regular gasoline” ($M = 6.3$, $SD = 2.3$, $r = .57$). Finally, the measure of environmental risk perceptions was subtracted from the measure of environmental benefit perceptions to create a *Net environmental benefits* measure ranging from -9 to $+9$ ($M = 1.9$, $SD = 3.3$, $r = -.12$). For each of the dependent variables, the possible range of values is -9 to $+9$, with positive values indicating a perception of greater benefits than risks and negative values indicating a perception of greater risks than benefits for the particular domain of interest.

Our measure of *Net economic benefits* was measured by asking respondents about their benefit and risk perceptions for biofuels in economic terms. We assessed respondent risk perceptions by averaging agreement with the following two statements: “Biofuels will increase fuel costs” and “Biofuels production will lead to an increase in the price of food” ($M = 5.6$, $SD = 2.3$, $r = .49$). We measured respondent benefit perceptions by averaging agreement with the following two statements: “Biofuels production will create more jobs” and “Developing domestic biofuels will help strengthen the U.S. economy” ($M = 6.2$, $SD = 2.4$, $r = .68$). Subtracting the risk perception measure from the benefit perception measure, created a measure of *Net economic benefits* ($M = 0.7$, $SD = 3.7$, $r = -.26$).

Our third dependent variable is a measure of *Net ethical/social benefits*. Ethical/social risk perceptions were measured by again asking respondents their level of agreement the following two statements and averaging them together: “Biofuel plants reduce the quality of life in surrounding communities” and “Recent increases in biofuels production have contributed to world hunger” ($M = 4.1$, $SD = 2.2$, $r = .45$). Ethical/social benefit perceptions were measured in the same manner by asking levels of agreement or disagreement with the following statements: “Biofuels

will help the U.S. maintain global leadership in science and technology,” and “Biofuels enable us to turn agricultural waste into energy” ($M = 6.4$, $SD = 2.3$, $r = .53$). Subtracting the Ethical/social risk perception measure from the benefit measure produced an overall measure of *Net ethical/social benefits* ($M = 2.3$, $SD = 3.4$, $r = -.17$).

Finally, we created a measure of *Net political benefits*. We measured the political risk perceptions by asking respondents their level of agreement with the following two statements: “Developing biofuels takes resources away from other renewable energy solutions, such as wind and solar” and “Government mandates to use more biofuels put unfair restrictions on U.S. industry” ($M = 5.1$, $SD = 2.2$, $r = .35$). Political benefit perceptions were measured by averaging responses to the following two statements: “Increasing production of biofuels will reduce our dependence on foreign oil” and “By investing in biofuels, the U.S. government can join the international fight against global warming” ($M = 6.1$, $SD = 2.5$, $r = .57$). Subtracting the political risk perceptions from the political benefit perceptions resulted in our overall measure of *Net political benefits* ($M = 1.0$, $SD = 3.5$, $r = -.13$).

Analytic framework

We tested our hypotheses and research questions using hierarchical ordinary least squares (OLS) regression models, entering independent variables into the regression based on their assumed causal order.⁷⁷ A key advantage of hierarchical regression models is that they allow us to examine the relative explanatory power of different blocks of predictors (e.g., demographics relative to knowledge) on dependent variables and to control for blocks of variables as they are entered into the model. This is an important consideration for a public issue like attitudes toward biofuels, about which there are few extant findings. Across all four regressions, the first block consisted of our three demographic variables: age, gender and education, the second block consisted of a measure of political ideology, the third block assessed media use, and the fourth block measured knowledge of biofuels. The final block of the regression models contained our interaction terms that were created by multiplying the centered values of the main effects variables. This was done to avoid issues of multicollinearity between the interaction term and its components.⁷⁷ In each of our

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Table 1. Regression predicting benefit vs. risk perceptions across each of the four domains

	<i>Environmental</i>	<i>Economic</i>	<i>Ethical/Social</i>	<i>Political</i>
<i>Block 1: Demographics</i>				
Education	.01	-.05	-.04	-.04
Sex (Male = 1)	-.08	-.13**	-.09*	-.13**
Age	-.12**	-.08	-.11*	-.10*
Incremental R ² (%)	1.8*	2.5**	1.9*	2.9**
<i>Block 2: Value predispositions</i>				
Party ID (Democrat = high)	.08	.13**	.04	.19***
Incremental R ² (%)	1.1*	2.1***	0.4	4.2***
<i>Block 3: Media use</i>				
TV political attention	.09	.07	.15*	.06
TV science attention	-.01	.01	-.01	.00
Newspaper political attention	-.04	-.17	-.11	-.20*
Newspaper science attention	.09	.11	.04	.15
Incremental R ² (%)	0.9	1.0	1.4	1.3
<i>Block 4: Knowledge</i>				
Biofuels knowledge	-.07	-.14***	-.09*	-.09*
Incremental R ² (%)	0.6	2.2***	0.9*	1.0*
<i>Block 5: Interactions</i>				
Television politics × Ideology	.08	.12**	.11*	.09*
Television science × Ideology	.01	.07	.06	.04
Newspaper politics × Ideology	.03	.09*	.06	.10*
Newspaper science × Ideology	-.02	.02	.02	.06
Incremental R ² (%)	1.0	2.1*	1.2	1.3
Total R ² (%)	5.4	9.9	5.7	10.8

Notes: * $p < .05$, ** $p < .01$, *** $p < .001$

Cell entries for all models are standardized regression coefficients while cell entries for the interactions in Block 5 are before-entry standardized regression coefficients

regressions, we examined the interactions between political ideology and each of our four media attention variables.

Results

Table 1 presents the standardized regression coefficients for the final regression models as well as the upon-entry standardized regression coefficients for the interactions in each of these models. As Table 1 illustrates, there is a consistent pattern of negative relationships between age and three of our dependent variables, suggesting that younger respondents are more likely to have greater net benefit perceptions. Similarly, there is a consistent pattern across three of our dependent variables of females being more likely than males to believe that the benefits of biofuels are greater than the risks. Interestingly, there was not a significant effect for education on any of the dependent variables.

The second block considers the main effects of political party identification. In response to research question 2, there is a generally positive effect of Democrat party identification on perceptions of benefits relative to risks for biofuels; however, this effect did not reach statistical significance across all of our regression models. In particular, Democrats were significantly more likely than Republicans to view greater net benefits in two domains: the economy and politics.

Next, our results show limited main effects of newspaper and television attention on perceptions of benefits relative to risks. Specifically, we found a significant main effect of political television attention on *Net ethical/social benefits* and a significant main effect of political newspaper attention on *Net political benefits*. Moreover, these two relationships operated in opposite directions with attention to political television positively impacting *Net ethical/social benefits* and political newspaper attention negatively impacting *Net political benefits*. Therefore, there is some evidence that

newspapers and television have different effects on biofuel benefit and risk perceptions, but there does not appear to be a consistent pattern across the four domains of interest.

The fourth block of variables considered the role of biofuels knowledge on the four dependent variables. Interestingly, a consistent relationship between biofuels knowledge and benefits relative to risks emerged from our analysis. There was a statistically significant negative relationship in three of the four regressions between knowledge and the dependent variable. That is, the more knowledgeable respondents in our sample tended to perceive fewer benefits relative to risks from biofuels than those with less knowledge about the subject. For the regression predicting *Net environmental benefits*, knowledge operated in the same direction but did not achieve statistical significance. Therefore, and in response to research question 1, there is rather strong evidence that as citizens become more knowledgeable about biofuels their perceptions of benefits relative to risks tend to decrease. This finding runs contrary to knowledge deficit models, which propose that a more scientifically literate society will be more supportive of science.

Based on the motivated reasoning literature we hypothesized that the influence of our media attention variables on biofuels attitudes would be moderated by political party identification of our survey respondents. As our results will show, we found evidence for this type of motivated reasoning among our partisan groups across three out of our four regression models tested. Specifically, Democrats appear inclined to think that biofuels will be largely beneficial, and therefore, tend to interpret the information they receive accordingly. This may be due in part to cues from party leaders, including President Obama, who has been adamant about the role of biofuels in “reducing America’s dependence on foreign oil and creating jobs here at home.”⁷⁸

Similarly, there is evidence of motivated reasoning among Republicans, who appear predisposed to oppose biofuels. As Republican respondents integrate and interpret new media information they tend to see fewer benefits relative to risks from alternative fuel. Again, this is not entirely surprising given some of the strong criticisms directed toward biofuels investment by Republican leaders. For example, Senate Minority Leader Mitch McConnell (R-Kentucky) has called

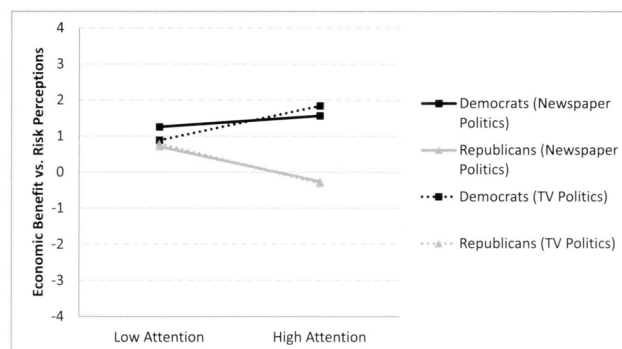


Figure 1. Interaction for media attention and party identification on Net economic benefits (scale only partially displayed).

investments in algae-based fuels a “pipe dream,” while Senator Kay Bailey Hutchison (R-Texas) has questioned the legitimacy of an energy policy that seeks to increase domestic production of renewables, including biofuels.⁷⁹ Next, we discuss the significant interactions.

When *Net economic benefits* is the dependent variable in our regression model, two interactions emerged as significant. Figure 1 depicts the interactions between political newspaper attention and partisanship and political television attention and partisanship. As illustrated, the influence of political newspaper attention differs in its effects on Democrats and Republicans. While Democrats tend to perceive greater net economic benefits as political newspaper attention increases, Republican net economic benefit perceptions decrease. In fact, the shift in benefit and risk perceptions for Republicans is large enough that at low attention levels Republican party identifiers perceive net economic *benefits* from biofuels, but at high attention levels they perceive net economic *risks*. Figure 1 also depicts a similar and slightly more pronounced pattern for the interaction of political television attention and ideology on the same dependent variable.

Turning to the *Net ethical/social benefits* interactions. Figure 2 depicts a significant interaction between political television attention and ideology. Once again, we see a pattern whereby Democrats tend to have greater benefit perceptions as their political television attention increases whereas Republicans benefit perceptions drop as their political television attention

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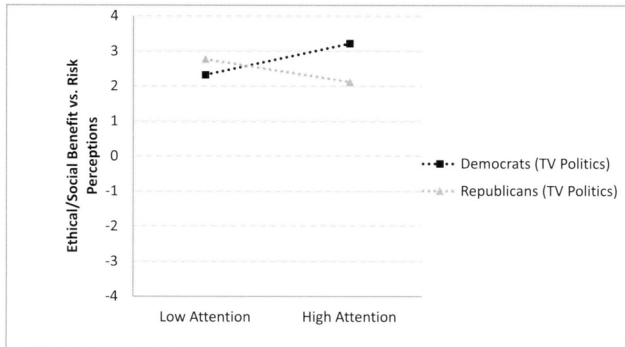


Figure 2. Interaction for media attention and party identification on Net ethical/social benefits (scale only partially displayed).

moves from low to high (i.e., as they pay closer attention).

Finally, our analysis examined the interactions between media attention and ideology for *Net political benefits*. As with net economic benefit perceptions, two interactions emerged as significant. Figure 3 depicts the significant interaction between political newspaper attention and partisanship as well as between political television attention and partisanship on *Net political benefits*. As with the previous interactions, there is a consistent pattern of Democrats perceiving greater benefits from biofuels as their political newspaper attention levels increase. Similarly, Republicans once again show a pattern of decreasing benefit perceptions as their political newspaper attention increases. And, as when *Net economic benefits* was the dependent variable, Republicans with high political newspaper attention actually perceive greater overall political risks than benefits from biofuels. Figure 3 also depicts a similar, though slightly less pronounced, pattern for the interaction of political television attention and ideology on *Net political benefits*. Based on the results of these interactions there is support for H_1 , but not H_2 .

Also of note is the more general finding that respondents tend to perceive greater *net ethical/social benefits* ($M = 2.34$) from biofuels than any of the other three domains. That is the scores on our measure of net ethical/social benefits tended to be higher than the scores on our measure of net benefits in all other domains. The next highest domain was net environmental benefits ($M = 1.89$), followed by net political benefits ($M = 1.01$), and finally, net economic benefits

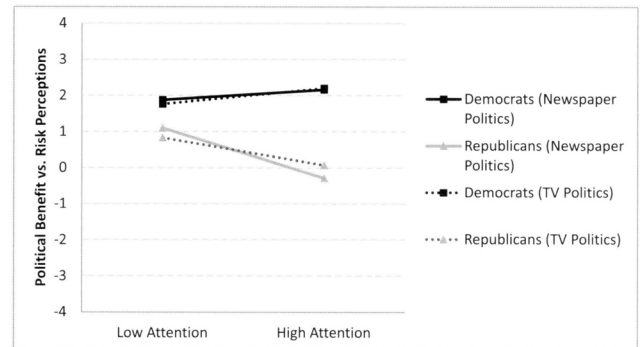


Figure 3. Interaction for media attention and party identification on Net political benefits (scale only partially displayed).

and risks ($M = 0.67$). A pair-wise t -test revealed that each of the mean differences were statistically significant ($p < .01$).

Discussion

This study provides useful perspective on the assessment of perceived benefits of biofuels, as well as the domains in which citizens perceive the greatest risks. Given the lack of research regarding public attitudes toward biofuels, this study has identified some of the factors influencing opinion formation toward biofuels. Our results corroborate other survey findings which found younger and female respondents to be more supportive of biofuels,¹⁷ while also expanding the applicability of those findings to areas of perceived benefits and risks.

Our gender finding is especially interesting, as the bulk of the risk perception literature suggests that women tend to be more risk averse and wary than men when it comes to evaluating a variety of potential hazards, including new technologies.^{80,81,82,83} Part of the explanation for this finding, however, may have to do with the clear ties between biofuels and issues related to the environment — particularly as biofuels have been lauded as an environmentally friendly, renewable fuel.¹¹ Research suggests that females are typically more supportive of measures to protect the environment.^{84,85} Thus, it may be that women are more likely to view the use of biofuels through the lens of environmental protection and as a superior alternative to fossil fuels. This may serve to reduce their

perceptions of risks overall, making females less risk averse toward biofuels than males. Of course, this is just speculative, but it is an issue worthy of further investigation.

Our focus with this research was on the influence of knowledge, partisanship, and news media attention on domain-specific benefit and risk perceptions of biofuels. We found significant impacts of knowledge on biofuels attitudes, as well as evidence of an ideological divide forming around the issue. Most importantly our study reveals a moderating role of partisanship on political media attention for our domain-specific measures. These findings suggest that attention to political content, both on television and in newspapers can have rather different effects on the risk perceptions of Democrats and Republicans. Before elaborating on these findings, however, we discuss some limitations of the study.

The first concern is related to measurement of some of our key variables. Unfortunately, due to data restrictions, we were unable to include measures of attention to science news online in the present analysis. As citizens are increasingly moving online for science information,⁸⁶ it is imperative to garner a better understanding of how they are engaging with Internet content. Future research should explore how partisan motivations influence online media consumption for related political and scientific issues. Additionally, our dependent variables were created by taking responses to two domain-specific risk perception statements and subtracting them from responses to a pair of benefit perception statements from the same domain. While this form of measurement is an improvement over more abstract, or single-item measures of benefit vs. risk perceptions,⁷⁶ it is not without its limitations. The primary problem with this assessment is that it assumes that individual benefit and risk perception statements will carry equal weight among respondents. In other words, our measures treated each of these four domains as equally relevant to respondents. While we have strong theoretical reasons for using these specific domains, based primarily on their prominence in debates over biofuels,⁷⁵ we leave the question of relative weighting to future research.

A second limitation concerns the nature of our survey sample. The respondents for this study came from a single U.S. state, rather than a more nationally representative sample. Therefore, it is important to not

overinterpret the findings. The results, while providing a useful look at how citizens in one state view biofuels, may not hold for the U.S. population as a whole. At the same time, this limitation is also a source of value given the economic and political relevance of the issue in Wisconsin.

A third problem relates to the issue of causality. As we relied on cross-sectional data for the current study, it is impossible to know the process whereby Democrats and Republicans are arriving at different conclusions about the benefit and risk perceptions of biofuels. It may be that partisanship is acting as a powerful heuristic that influences both the types of political content that respondents turn to as well as how respondents engage with that content. However, we cannot rule out alternative explanations, or the possibility that prior opinions about biofuels shape the type and amount of news media information that citizens consume.

Finally, our understanding of public opinion about biofuels is hampered by the relatively low *R*-squared values from our regressions. Our models were able to explain at most about 11 percent variance, while two of our regressions explained less than 6 percent of the variance in the dependent variables. Of course, it is not entirely surprising that we were able to explain such small portions of the variance given the lack of empirical research exploring public assessments of biofuels benefits and risks. This study offers a baseline understanding of how citizens arrive at such perceptions.

With these considerations in mind, we nevertheless found interesting relationships regarding the impacts of knowledge, partisanship and media on assessments of biofuels. Unlike other life sciences issues (e.g., nanotechnology, stem cell research, and biotechnology), knowledge levels negatively predicted attitudes toward biofuels. Specifically, the more knowledgeable members of our sample tended to score lower on our measures of biofuels benefits relative to risks—a finding that runs contrary to much social science work on the relationship between knowledge levels and scientific support. This finding is especially surprising given the importance of biofuels in Wisconsin, both as a fuel for exporting and as a source of employment in many rural communities. These findings may suggest an impending public backlash toward the industry as citizens become more familiar and knowledgeable about the industry.

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Moving away from knowledge, our study found that self-identified Democrats are more positive in their evaluations of biofuels than Republicans. This suggests that biofuels may be following other scientific issues (e.g., stem cell research) in becoming a heavily politicized issue characterized by a strong ideological divide. Finally, and in line with the motivated reasoning literature, our study revealed a moderating role of partisanship on political media attention for our domain-specific risk perception measures. These findings suggest that attention to political content, both on television and in newspapers, can have polarizing effects on partisans concerning the evaluation of biofuels.

Based on the similar, positive opinions toward biofuels being expressed by political elites on both sides of the aisle at the time this survey was conducted, it does not appear that the public is responding directly to party when forming evaluations of this emerging technology. More likely, it may be that individuals are using their political identification as a heuristic cue that leads them to selectively attend to media sources consistent with their political outlook (Fox News for Republicans and CNN, MSNBC, etc. for Democrats.⁶⁹) This may result in a tendency for Republicans to hear less positive opinions toward biofuels, such as those expressed by Glenn Beck, who once blamed biofuels and ethanol for increases in food prices and subsequent food riots.⁷⁰ On a related note, it may be that political partisans link biofuels to media discussions of renewable energies and global climate change more broadly. While Democrats may think of biofuels in terms of a potential renewable energy solution to combat climate change, Republicans may be focusing more on the government-imposed mandates for biofuels development and the financial incentives provided to the biofuels industry. As media attention grows, these linkages can be expected to grow and lead to further polarization in opinions.

While Democrats and Republicans with low levels of political media attention appear to have similar risk perceptions about biofuels, these views may begin to diverge as the debate over biofuels continues to play out publicly. That is, attitudes are likely to polarize as party identifiers learn more about the issue through newspapers and television, with Republicans becoming more critical, and Democrats becoming more accepting in their evaluations of the alternative fuel.

These effects may become more pronounced once different organizations and advocacy groups seize upon different frames for presenting biofuels content.^{71,87} Importantly, we did not observe similar divergent effects between Democrats and Republicans based on their science media attention. This may be because portrayals in science-focused media are decidedly less politicized, containing more factual information and less opinionated views that may be received differently by the two groups. Or, it may be that both Republicans and Democrats are turning to the same sources for this information (e.g., television programs such as Nova). Future research should investigate these possibilities.

While this study has identified some key dynamics in attitudes toward biofuels, future research will need to examine a number of additional issues to arrive at a more nuanced understanding of opinion formation surrounding biofuels. Our understanding of the opinion formation process is hampered by lack of knowledge about what exactly coverage of biofuels media content looks like. Although we have suggested that anti-biofuels comments made by pundits like Glenn Beck are more likely to be heard by Republicans, we cannot confidently say that traditionally conservative news sources are less accepting of biofuels. Nor do we mean to suggest that traditionally liberal media outlets are blindly supportive of biofuels as an alternative energy source. Clearly, a better understanding of the nature of biofuels media discourse is warranted. A content analysis of biofuels coverage would prove especially helpful in this regard. In addition, it may prove helpful to examine opinion formation about *specific* biofuels, as opposed to the more general approach we employed. For instance, opinions about corn-based ethanol may differ dramatically from opinions about ethanol derived from algae or other non-food crops. Future research will need to take this into consideration when exploring public reactions to biofuels.

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