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Exploring the Adaptation-mitigation Relationship: Does Information on the Costs of Adapting to Climate Change Influence Support for Mitigation?

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ABSTRACT

Can information about adaptation costs influence citizens' willingness to support climate change mitigation? Some scholars are concerned that policy discussions on adaptation might present climate change as a more manageable problem, and therefore crowd out mitigation efforts. On the other hand, providing information on adaptation costs may sensitize citizens to these costs, thereby increasing their willingness to support mitigation. To assess these conflicting predictions, we fielded a web-based survey experiment using a sample of 2,000 US-based respondents. We presented the respondents with a hypothetical newspaper article regarding a proposed gasoline tax (a mitigation strategy) and measured the support for this proposal across different treatment groups. In the control group, the respondents were told that failure to mitigate climate change could result in a potentially catastrophic outcome, whereas in each of the treatment groups the respondents were provided with information concerning possible adaptation costs. The respondents were then asked about their willingness to support a gasoline tax. Our key finding is that the provision of information about adaptation costs leads to a small increase in the respondents' willingness to support mitigation efforts. Furthermore, we find that this effect becomes larger when the information regarding adaptation costs is made more specific.

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Introduction

Climate change is among the most important issues of our times. The scientific case for climate change mitigation is an overwhelmingly powerful one. Yet the political case for mitigation is somewhat weaker for various reasons. First, given the mismatch between benefits and costs, mitigation (especially via new regulations) imposes concentrated costs on a few easily identifiable sectors (within and across countries) but creates a non-excludable global public good that benefits all (Lowi, 1964; Wilson, 1980). Consequently, the policy losers—those who bear the policy costs—have strong incentives to mobilize against new regulations, while policy supporters—those benefiting from the policy—face weaker incentives in this regard (O'Brien & Leichenko, 2003). Second, although China, India, and other developing countries have agreed to emissions reduction targets at the United Nations Climate Change Conference in Paris in 2015 (COP 21), and have made

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considerable strides in installing solar and wind energy generation capacity, these are voluntary and non-binding (see Liu & Goldstein, 2013; Safi, 2016; Salim & Rafiq, 2012). Consequently, some might argue that these countries will continue to benefit from "carbon leakages" (the relocation of carbon intensive industries from carbon-regulated jurisdictions to the non-regulated ones)[1] that will probably negate their mitigation efforts. Third, in the context of US policy debates, attention to mitigation might be crowded out by more immediate and high-profile problems such as the investigations concerning Russian interference in the 2016 US presidential elections, Brexit and the future of the European Union, the refugee crisis, and terrorism.

Because new scientific reports and additional high-level summits may not lead to desired mitigation outcomes, we suggest an approach that explicitly links adaptation and mitigation. We test a hypothesis examining whether focusing policy attention on adaptation costs will lead to greater support for mitigation efforts, or will instead undermine them. In doing so, we place the adaptation-mitigation debate within the broader literature suggesting that risky behavior is actually encouraged when actors are provided with remedies reducing the negative impact of such behavior (Evans, Milfont, & Lawrence, 2014; Howell, Capstick, & Whitmarsh, 2016; Peltzman, 1975; Streff & Geller, 1988).

Following Carrico, Truelove, Vandenbergh, and Dana (2015), we identify two broad causal pathways and test their observable implications. Environmentalists suggest a focus on adaptation is likely to dampen, if not crowd out, mitigation efforts. This coheres with the "risk compensation hypothesis" which suggests that remedies to reduce the impacts of risky behaviors can unintentionally encourage those behaviors. However, there is an alternative pathway to consider. In this case, the intuition is that opposition to mitigation can, in part, be attributed to the lack of appreciation of the costs of climate change. If so, information on adaptation costs could sensitize individuals to the personal costs they will have to bear if climate change is not mitigated. After all, *ex ante* preventive action is incentivized if the actor is told of the cost of rehabilitation *ex post*. This, in turn, could increase the support for mitigation. This coheres with the "risk salience hypothesis" which suggests that information about the consequences of risky behavior may enhance the perceptions of risks from such actions, and therefore discourage such behaviors (Carrico et al., 2015).

Adaptation scholars note the inevitability of changes in the climate even if all countries meet aggressive mitigation targets (Dolšak & Prakash, 2018; IPCC, 2014; Javeline, 2014; Lobell et al., 2008; Smit, Burton, Klein, & Wandel, 2000). These changes will manifest in a variety of ways including extreme weather events, drought, food shortages, rising sea levels, new diseases, and overworked electrical grids (Lobell et al., 2008; Smit et al., 2000). Thus, even by itself, the political and economic logic of adaptation might be compelling. Further, while mitigation requires global collective action and produces global public goods, adaptation can be successful even when undertaken unilaterally at the local level. Importantly, because adaptation-related investments create local benefits, not global public goods, adaptation does not suffer from the same intensity of the free rider problem (Urwin & Jordan, 2008).

However, scholars acknowledge that a focus on adaptation may dampen, if not crowd out, mitigation efforts (Felgenhauer & Webster, 2013; Giddens, 2009; Hasson, Löfgren, & Visser, 2010; Howell et al., 2016; Moser, 2012; Pielke, Prins, Rayner, & Sarewitz, 2007; Ruhl, 2010; Victor, Kennel, & Ramanathan, 2012). If people believe that they can deal with the consequences of climate change, they may be less likely to invest in proactively mitigating it.

To test the conflicting predictions of a relationship between adaptation and mitigation, we fielded a web-based survey experiment using a sample of 2,000 US-based respondents. We presented the respondents with a hypothetical newspaper article regarding a proposed gasoline tax (a mitigation strategy that imposes direct and immediate costs on the respondents) and measured the support for this proposal across different treatment groups. In the control group, the respondents were told that a failure to mitigate climate change could result in a potentially catastrophic outcome, whereas in each of the treatment groups the respondents were provided with information concerning different adaptation costs. The respondents were then asked to indicate their intention to pay for the gasoline

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tax. The crucial finding to emerge from this study is that providing information about the possibility of adaptation *does not* undermine support for mitigation. Instead, the provision of information about adaptation costs leads to modest increases in the respondents' willingness to support mitigation efforts. At the same time, we find that respondents become more willing to support mitigation efforts when they are provided with more specific information about the likely adaptation costs.

Climate change adaptation and mitigation

The Intergovernmental Panel on Climate Change (IPCC) defines mitigation as an intervention to reduce emissions or to enhance sinks of anthropogenic greenhouse gases. Adaptation is defined as activities, processes, practices, or structures that reduce vulnerability of communities and countries to climatic change and variability, as well as those that reduce the potential damage caused by global climate change (Dolšak & Prakash, 2018). While climate change policy historically focused on mitigation (see Carrico et al., 2015 and sources cited therein), there is now a broad agreement that "(a)daptation and mitigation are complementary strategies for reducing and managing the risks of climate change" (IPCC, 2014, p. 17). Scholars call for scientific effort to examine synergies and tradeoffs between them, including competitions, negative consequences, policy timing, and sequencing (Demuzere et al., 2014; Klein et al., 2007; Landauer, Juhola, & Söderholm, 2015; National Research Council, 2010) as well as for studies examining information used to make decisions (Moser, 2012).

Some suggest that adaptation is an unclear concept (Ford & Berrang-Ford, 2016; Ford, Berrang-Ford, & Paterson, 2011). For example, adaptation may be reactive (weather proofing structures after an extreme weather event) or proactive (building a seawall in anticipation of a rise in sea-level). Second, while both mitigation and adaptation are susceptible to concept overstretch and capture by actors that seek a policy under the garb of a different label, adaptation policies can subsume any policy that improves a community's resilience (Dolšak & Prakash, 2018). For example, if a public building in a municipality needs modernization, then replacing it with a newer (and more weather-resistant) building can be deemed as an adaptation policy. Hence, it is critical that adaptation scholars carefully assess whether a policy was indeed motivated by an objective to improve community resilience to climate change as opposed to some other consideration (Dolšak & Prakash, 2018).

While both mitigation and adaptation require effective risk management, the question of how they relate to each other remains unsettled (Ingham, Ma, & Ulph, 2013; Kane & Shogren, 2000; Klein et al., 2007; Koks, Jongman, Husby, & Botzen, 2015; Parry, 2009; Shalizi & Lecocq, 2009; Yohe & Strzepek, 2007). Those who consider them complements examine the question of the "optimum mix" where the adaptation option reduces the costs of immediate mitigation (Bosello, Carraro, & De Cian, 2013) and mitigation buys time and reduces costs of adaptation (Ingham, Ma, & Ulph, 2006). Others examine trade-offs between mitigation and adaptation. The trade-offs are more likely for adaptation activities that co-occur with mitigation, such as investments in enhancing adaptive capacity. In this case, these activities might compete for resources (Felgenhauer & Webster, 2013; Hasson et al., 2010; Klein et al., 2007; Moser, 2012; Tol, 2005). Further, learning about adaptation options may reduce public support for mitigation (Carrico et al., 2015; Giddens, 2009; Howell et al., 2016; Moser, 2012; Pielke et al., 2007; Ruhl, 2010).

The question of whether adaptation undermines or enhances individuals' support for mitigation can be explored by drawing on the social psychology literature on whether individuals become more or less likely to undertake risky behavior when suitable remedies are available. As noted above, scholars worry that a public discussion of adaptation strategies might undermine popular support for mitigation. Indeed, Pielke et al. (2007, p. 597) note that "Yet for much of the past two decades the mere idea of adapting to climate change became problematic for those advocating emissions reductions, and was treated with the same distaste that the religious right reserves for sex education in schools." While mitigation and adaptation are now both considered to be essential for managing climate change, concerns about trade-offs between them remain (Moser, 2012).

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Theoretically, the argument against adaptation can be attributed to the "risk compensation hypothesis" which suggests that actions to reduce the negative consequences of risky behaviors may actually encourage such behaviors (Carrico et al., 2015; Evans et al., 2014; Howell et al., 2014; Peltzman, 1975; Streff & Geller, 1988). We identify three separate factors that motivate behavior within this causal pathway.

First, actors may believe that they have protected themselves from the consequences of risky behavior. Therefore, they believe that even if they continue with this behavior, the risk of the problem striking them is rather low. For example, the mandatory use of seatbelts may encourage risky driving (Cohen & Einav, 2003). The motorist might feel that he or she has some sort of protection against the ill effects of a car crash and might therefore be motivated to drive fast or recklessly. A secondary outcome might be that the actor might begin to believe that this precautionary measure protects him or her not only from the direct effect of risky behavior, but also some indirect ones. For example, individuals might mistakenly believe that certain forms of birth control protect them not only from unwanted pregnancies but also from sexually transmitted diseases. Consequently, the widespread availability of birth control pills might encourage risky sexual activities (Anderson et al., 1990).

Second, Carrico et al. (2015) note that the risk compensation hypothesis can also be attributed to the "rebound effect" (Greening, Greene, & Difiglio, 2000) that scholars have explored in the context of issues such as energy efficiency. The idea is that energy saving innovations may lead consumers to over-consume energy, and consequently, they "take back" some of the energy savings (Binswanger, 2001; Herring, 2006; Swim et al., 2009). However, other scholars do not find a rebound effect with the introduction of hybrid cars such as the Toyota Prius (de Haan, Peters, & Scholz, 2007).

Third, after having undertaken one type of environmental action, individuals might come to believe that they have paid their moral dues and therefore do not need to undertake other types of action. This is referred to in the psychology literature as "moral self-licensing" (Mazar & Zhong, 2010; Merritt, Effron, & Monin, 2010). As a result, individuals who have incurred costs to adapt to climate change might feel less motivated to support mitigation efforts.

However, it is important to note that the issue of "risk compensation" should not be confused with a moral hazard problem. In the case of moral hazard, risky behavior is encouraged because actors do not bear the full consequences of their actions. In the case of risk compensation, actors still bear the full consequences but nonetheless undertake the risky behavior because they believe they have protected themselves or feel that the risk of the problem striking them is rather low, compared to the benefits they might gain from their behaviors. Emitting greenhouse gases can be considered an example of such risky behavior. If actors believe that they will be able to adapt to the negative consequences of climate change, they will presumably be less motivated to invest in mitigation policies.

The opposing argument—that information about adaptation costs might actually increase popular support for mitigation—finds theoretical support in the "risk salience hypothesis" (Carrico et al., 2015). In this case, the causal pathway suggests that when actors are provided with information about the consequences of their risky behavior, they change their perceptions of the risks involved and become discouraged from engaging in such behavior (Herzenstein, Posavac, & Brakus, 2007; Yang, Rickard, Harrison, & Seo, 2014). For example, studies have suggested that graphic warning labels on cigarette packs can, under certain conditions, deter smoking (O'Hegarty et al., 2006; Thrasher, Rousu, Hammond, Navarro, & Corrigan, 2011). The reason is that the smoker is provided with a sense of the consequences of smoking in a visually compelling format, thereby leading to a better understanding of how smoking may impact his or her health. In such studies, scholars typically find that health warnings expressed using visuals are more effective than those that rely only on text. This suggests that the specificity of the information is an important factor in determining the impact of the message.

According to the risk salience hypothesis, providing information about the likely costs of adaptation efforts will increase the perceived risks of climate change and thereby motivate actors to support mitigation. When citizens are faced with the prospect of paying for adaptation, they will be

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forced to recognize the true costs that ignoring global climate change will have for themselves and their communities. Consequently, citizens will be less likely to invoke the "China excuse"[2] to justify policy inaction (Dolšak & Prakash, 2015) and more willing to support climate change mitigation. Viewed in this way, discussions about adaptation can be interpreted as a strategy to educate citizens of the costs of ignoring climate change. If so, when informed about adaptation costs, individuals may begin to form a more concrete picture of the negative consequences of ignoring mitigation (Evans et al., 2014; Smith & Leiserowitz, 2012).

Arguably, how the information on the potential costs of addressing climate change is conveyed might influence individuals' willingness to support mitigation policies. Carrico et al. (2015), however, find that the way in which information about adaptation is presented has somewhat inconsistent effects on support for mitigation; instead, political ideology tends to dominate the framing effects. One could argue that the impact of information changes when actors directly observe these costs via an extreme weather event. For example, if someone's house were to be damaged by a hurricane, and if that hurricane could plausibly be attributed to climate change, might we expect the owner's willingness to support mitigation efforts to increase (Osberghaus, 2015)? Konisky, Hughes, and Kaylor (2016) test how the frequency and severity of extreme weather events influence individuals' perceptions of climate change. However, very much like Carrico et al. (2015), Konisky et al. find that ideology is the dominant factor shaping concerns about and belief in climate change.

Building on the prior literature, we test the adaptation-mitigation relationship by exploring how different (and specific) ways of providing information on adaptation costs might shape willingness to support mitigation. Our survey experiment differs from previous studies in three important ways. First, it offers a more concrete operationalization of mitigation costs via a gasoline tax, instead of seeking to understand the support for mitigation in more general terms. The idea of a gasoline tax is a well-known policy instrument that has been used in several other studies of willingness to support climate change mitigation. A gasoline tax can be easily converted to an increase in actual costs for the individual, and it clearly links to the use of fossil fuels and risks of global climate change (Viscusi & Zeckhauser, 2006, p. 161).

Second, our study tests different ways to convey information on adaptation costs, ranging from less specific to more specific information inputs. This is to ensure that respondents clearly understand that the mitigation costs they are being asked to bear are related to climate change. Third, it operationalizes adaptation in ways that is more easily understood by members of the public. Much of the adaptation literature focuses on governmental (or firm-level) policies on adaptation without investigating who will pay for them. While we do not differentiate between private and public provision of adaptation (Tompkins & Eakin, 2012), we focus on a case where adaptation costs can be unitized and are directly borne by individuals. This approach allows individuals to compare the costs they have to bear for adapting to climate change in relation to the costs of mitigating climate change.

Experimental design and methods

We recruited a sample of 2,000 US respondents using Amazon Mechanical Turk (MTurk).[3] After consenting to participate in the study, each respondent was randomly assigned to one of eight different treatment groups and asked to read a version of a fictitious newspaper article discussing a proposed gasoline tax. The article reported that a leading scientific organization (a fictitious group called "Scientists for a Sustainable America") had called on the US government to adopt a gasoline tax as part of an effort to limit carbon dioxide emissions. The content of the article varied across the treatment groups in terms of how information on future adaptation costs was presented to the respondents. All versions of the article, however, described the rationale for climate change mitigation via a gasoline tax as follows: (1) carbon dioxide emissions are one of the major contributors to global warming; (2) the transportation sector in the US accounts for a large share of these emissions; hence (3) a gasoline tax could significantly reduce global climate change.

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The experimental manipulation involved variation on two dimensions: the first is the level/specificity of adaptation costs (4 levels); and the second is the level of ancillary benefits (2 levels). Consequently, we worked with a 4 × 2 factorial design. The first dimension presented different magnitudes, types, and specificities of adaptation costs. We hypothesize that providing information on adaptation costs could influence the intentions to pay for mitigation in various ways. One possibility is that as the information becomes more precise—for instance, if we express anticipated adaptation costs in terms of an actual dollar amount—the risk of climate change will become more salient to the respondent. This will reduce the "psychological distance" (Evans et al., 2014; Spence, Poortinga, & Pidgeon, 2012) between the individual and climate change, causing the respondent to be more likely to support climate change mitigation. On the other hand, some respondents may react to a specific dollar amount by inferring that the costs of adapting to climate change will be lower than they had originally expected, in which case they may become less willing to pay for mitigation (as the risk compensation hypothesis would predict).

Another possibility is that the effect of providing information about adaptation costs will depend upon which types of costs are discussed. Because much of the discussion on the regulatory costs of mitigating climate change focuses on the transportation and electricity sectors (e.g. through gas taxes or coal use regulations for power plants), an adaptation message that focuses on higher electricity costs should have more resonance than a message that highlights increased costs in other sectors, such as food or healthcare, where the connection to climate change is not so obvious. The IPCC's Fifth assessment report focusing on adaptation needs in North America clearly outlines how climate change will impact electricity generation. Furthermore, Wietze and van der Laan (2015) summarize various investments power companies will need to undertake to adapt to the impact of climate change on their generation capacity, consumption patterns, and infrastructure.

At the same time, one might argue that information about adaptation costs affecting multiple sectors will be perceived differently than information focusing on the costs in only one specific sector. If so—and consistent with the risk salience hypothesis—climate change will appear more threatening when the respondents realize that they will likely face adaptation costs in multiple areas of their lives. On the other hand, one could argue the opposite. In this case, as the social dilemma literature suggests, information about adaptation costs in multiple sectors may convey an impression of the vastness of the problem and the resulting futility of efforts aimed at mitigation (Costanza, 1987; Hasson et al., 2010).

For the purposes of testing these hypotheses about the specificity of adaptation costs, we compared the respondents' willingness to pay for a gasoline tax after being asked to read a newspaper article that adopted one of the following four frames:

(1) *Control.* This version of the article (shown in Figure 1 of the supplementary information) presents an account of climate change in which adaptation is not even considered a possibility. To reinforce the contrast with the other three versions of the article in which the possibilities (and likely costs) of adaptation are discussed, this version of the article notes that a failure to take steps towards mitigation would likely lead to an "environmental catastrophe." [4]
(2) *Electricity.* The frame suggests an anticipated increase in the cost of electricity as a likely consequence of climate change, but does not provide a specific estimate of the cost involved;
(3) *Electricity $500.* The frame notes that the anticipated increase in the cost of electricity is likely to amount to $500 per year for a typical US household;[5]
(4) *Electricity & Food.* The frame notes that adaptation costs would be reflected in increased electricity tariffs and food prices but does not provide a specific estimate of the likely costs involved.

The exact language used to describe each of these adaptation scenarios is shown in Table 1 below. (To view the entire article, please refer to Figure 1 of the supplementary information.)

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Table 1. Text used to manipulate the adaptation costs in each of the conditions.

Types of adaptation costs discussed	Manipulated text
No adaptation option	"Nobody wants to have to pay any more taxes," the group's president, Peter Baker, said at a press conference on Tuesday. "But unless we take some meaningful action soon to slow down the rate of global warming, we could face an environmental catastrophe in the years to come."
Higher electricity costs, unspecified amount	"Nobody wants to have to pay any more taxes," the group's president, Peter Baker, said at a press conference on Tuesday. "But unless we take some meaningful action soon to slow down the rate of global warming, we're going to end up paying for it in many other ways."
	Mr. Baker cited rising costs of electricity as one example. If the problem of global warming is not addressed, periods of extreme heat and cold will put more pressure on an already overstretched electric grid. The costs of the necessary upgrades will ultimately have to be passed on to consumers.
Higher electricity costs, specific amount	"Nobody wants to have to pay any more taxes," the group's president, Peter Baker, said at a press conference on Tuesday. "But unless we take some meaningful action soon to slow down the rate of global warming, we're going to end up paying for it in many other ways."
	Mr. Baker cited rising costs of electricity as one example. If the problem of global warming is not addressed, periods of extreme heat and cold will put more pressure on an already overstretched electric grid. The costs of the necessary upgrades will ultimately have to be passed on to consumers.
	According to a study commissioned by the organization, these increased electricity charges will cost the average American household around $500 per year.
Higher electricity and food costs, unspecified amounts	"Nobody wants to have to pay any more taxes," the group's president, Peter Baker, said at a press conference on Tuesday. "But unless we take some meaningful action soon to slow down the rate of global warming, we're going to end up paying for it in many other ways."
	Mr. Baker cited rising costs of electricity and food as two examples. If the problem of global warming is not addressed, periods of extreme heat and cold will put more pressure on an already overstretched electric grid. The costs of the necessary upgrades will ultimately have to be passed on to consumers.
	Food prices are also likely to rise as the agricultural sector struggles to adapt to periods of prolonged drought.

The second dimension of the experimental design pertains to the ancillary benefits of mitigation via a gasoline tax. Because climate change mitigation creates a global public good, its provision is vulnerable to free riding (Olson, 1965). However, some mitigation policies such as a gasoline tax may create local ancillary benefits that are appropriated by the local population. Prior research suggests that actors might be willing to contribute to a global public good with ancillary local benefits. For example, Dolšak (2001, 2009) finds that countries were more likely to ratify the Kyoto Protocol when they also experienced high levels of local air pollution that emanated from the sources that generate greenhouse gas emissions. Similarly, Longo, Hoyos, and Markandya (2012) find that individuals' willingness to pay for climate change mitigation is substantially higher when ancillary benefits are considered. These actors might then justify the costs of mitigation by invoking the local benefits mitigation measures might generate. Based on this logic, the frames the respondent were asked to read varied between: (1) providing no mention of ancillary benefits in the article; and (2) noting that a gasoline tax would be likely to produce less congested highways and improved air quality. To highlight these benefits, the frame included the following sentence: "Supporters claim that the gas tax will also bring other benefits, such as less congested highways and improved air quality." (The example of the article provided in Figure 1 of the supplementary information does not mention any ancillary benefits.)

After having read the version of the article to which they were randomly assigned, the respondents were asked to indicate their intention to pay for the proposed gasoline tax as a part of an effort to combat global climate change.[6] They were presented with a price card that listed the

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following tax levels (in cents per gallon): 0, 5, 10, 20, 30, 40, 50, 60, 70, 80, and greater than 80 cents per gallon.[7] Each option also included an estimate of the annual cost per driver based upon the assumption that the average US driver consumes 500 gallons of gasoline per year.[8]

The respondents were then directed towards a series of follow-up questions designed to capture their more general levels of concern for the environment, as well as political and demographic characteristics that other studies have found to be associated with willingness to support global climate change mitigation (see Carrico et al., 2015; Dupont & Bateman, 2012). We also included attention and manipulation checks.

Results of the survey experiment

We fielded our survey on MTurk on November 12, 2015 and received all 2,000 responses by the end of that day. At that point in time, preparations were underway for COP 21 in December 2015 that culminated in the adoption of the Paris Agreement. In the previous year, the US had struck an agreement with China to work together on tackling climate change and many observers were cautiously optimistic about the possibility of achieving a major multinational climate agreement in Paris. Moreover, the US public was by then starting to become increasingly aware of the dangers posed by climate change. According to a survey conducted by the Pew Research Center in the spring of 2015, 45% of US respondents indicated that they consider climate change to be a "very serious problem" (Pew Research Center, 2015).

After excluding the respondents who performed poorly on the attention and manipulation checks, we were left with a total of 1,623 observations.[9,10] Of the respondents who met the criteria for remaining in the sample, the demographic profile appears to be fairly typical of an MTurk sample (see Berinsky, Huber, & Lenz, 2012): the ratio of men to women is 52:48; the median age is 33; the median income lies somewhere between $40,000-$60,000; 52% are college graduates; 40% are parents; 42% identify as Democrats; 19% identify as Republicans; and 31% identify as independents.[11]

The distribution of responses on the willingness-to-pay scale (aggregated across all experimental conditions) is shown in Figure 1. As these data reveal, around 28% of our respondents were not

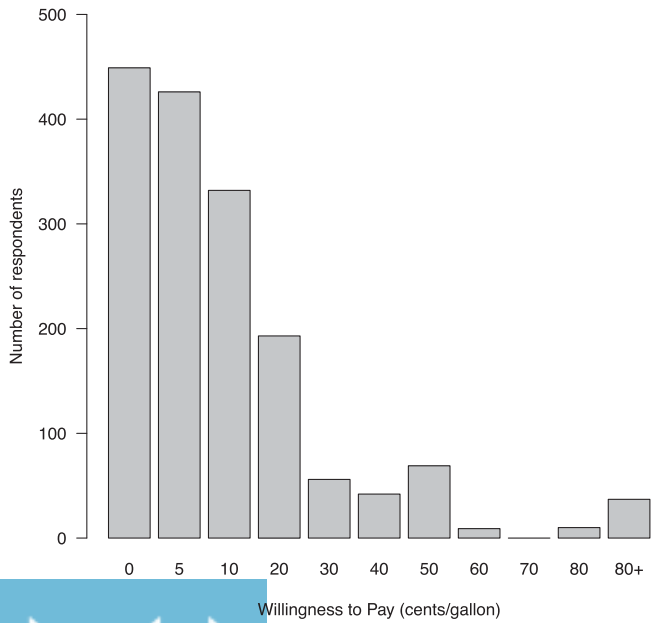

Figure 1. Distribution of the Dependent Variable Across All Treatment Conditions.

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willing to pay any additional gas tax to mitigate the effects of global warming; 47% of our respondents were willing to pay relatively modest amounts of 5 or 10 cents per gallon; and the remaining 26% were willing to pay amounts of 20 cents per gallon or higher.[12]

Figure 2 considers the effects that each of the experimental conditions has on the proportion of respondents willing to pay for the gas tax across a range of different levels of the tax. For instance, the upper-left panel shows the effects of each of the conditions on the respondents' willingness to pay 10 cents per gallon or higher. Here we can see that the proportion of respondents willing to pay for the gas tax is higher under each of the treatment conditions than it is in the control group. For example, in the case of the "Any Costs" condition (i.e. collapsing across all three treatment groups that involve the discussion of adaptation costs), we find that 48% of the respondents are willing to pay 10 cents or more per gallon, whereas in the control group (i.e. where there is no mention of adaptation costs), only 42% of the respondents are willing to do so ($z = 2.07$; $p = 0.04$). For each of the individual treatment groups, as well as the ancillary benefits condition, it appears that the sample sizes are too small to detect statistically significant differences relative to the control. As we vary the threshold used to dichotomize these responses, we find that the statistical significance of these differences varies. For instance, at a tax of 30 cents per gallon or higher, 15% of the respondents are willing to the pay the tax in the "Any Costs" condition, whereas only 10% are willing to do so in the control group ($z = 2.61$; $p = 0.01$). However, we do not find a statistically significant impact of the ancillary benefits treatment at any of level of the gas tax.

What is clear from these charts is that providing respondents with information about the costs of adaptation does not seem to be causing them to become less supportive of climate change mitigation

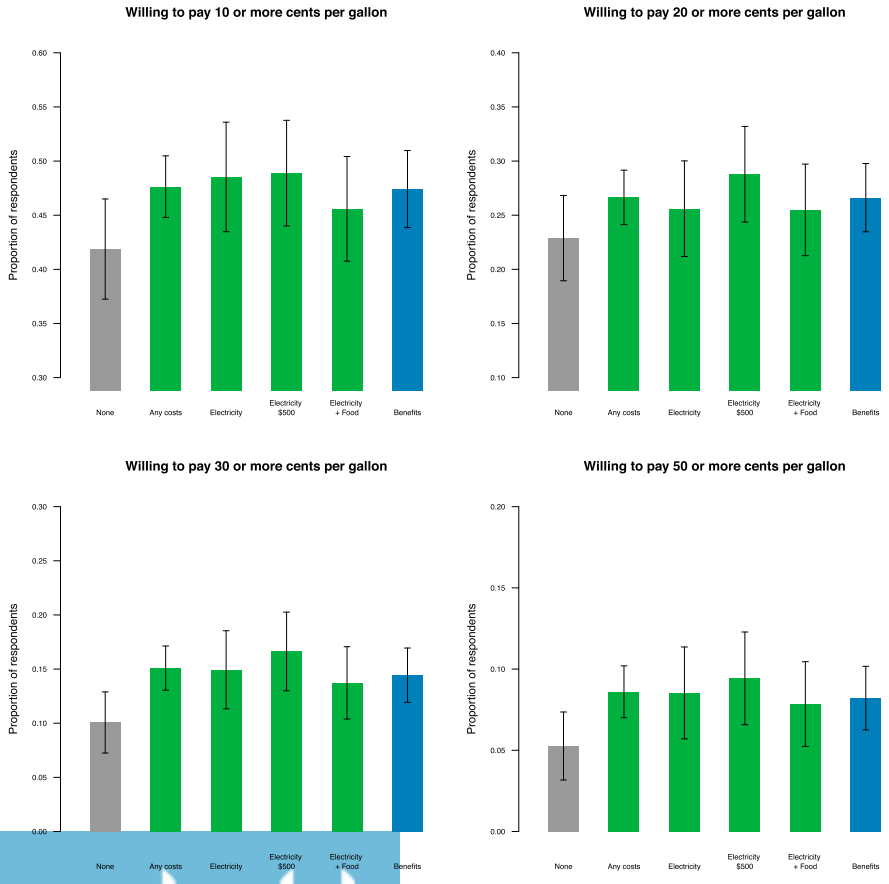

Figure 2. Willingess to Pay for the Gasoline Tax Across Treatment Conditions.

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efforts. Instead, the results suggest a modest change in the opposite direction: the respondents who were provided with information about adaptation costs were, on average, more likely to support higher gasoline taxes than those who were not. Furthermore, the specificity of information on adaptation costs appears to make a difference, although these results are merely suggestive. Respondents who were provided with information suggesting that adaptation will result in electricity costs increasing by an average of $500 per annum tend to exhibit the highest levels of support, whereas the less specific treatments—those that mentioned costs with unspecified amounts, whether in the electricity sector only or in both the electricity and food sectors—showed less of an increase in willingness to pay.[13] Although these effects are modest, it is important to keep in mind that many environmental activists have been working under the assumption that we might find an effect in the *opposite* direction—i.e. where discussion of adaptation costs would reduce support for mitigation efforts.

In order to provide a more systematic test of the impact of these manipulations across the full range of tax levels, we estimated a series of ordered probit models in which the respondents' intention to pay for the gasoline tax was regressed on dummy variables for each of the treatment conditions.[14] The results are shown in Table 2. (Note that in this table the numbers in parentheses are p-values, rather than standard errors.) We begin with a very simple model in which the respondents' intention to pay is regressed on two dummy variables—one indicating whether the respondent was exposed to any information about adaptation costs (*Any Costs*), and the other indicating whether the respondent was provided with information about the possible ancillary benefits associated with the new tax (*Ancillary Benefits*). Here we see that the provision of information about adaptation costs leads to a statistically significant increase in support for the tax ($p = 0.05$), whereas the provision of information concerning ancillary benefits shows no statistically significant relationship. In terms of its substantive effect size, Model 1 predicts that, for a respondent with median levels of the various demographic covariates, providing information about adaptation costs will cause the expected probability of supporting a gas tax of 30 cents or more per gallon to increase from 0.13 to 0.17.

Table 2. Ordered probit models of willingness to pay for a new gasoline tax. The numbers in parentheses are p-values, not standard errors.

	Model 1	Model 2	Model 3	Model 4
Any costs	0.12		0.17	
	(0.05)		(0.00)	
Electricity		0.12		0.18
		(0.10)		(0.02)
Electricity $500		0.13		0.22
		(0.07)		(0.00)
Electricity & Food		0.09		0.12
		(0.21)		(0.10)
Ancillary Benefits	0.05	0.05	0.05	0.05
	(0.36)	(0.36)	(0.40)	(0.39)
Male			0.11	0.11
			(0.06)	(0.06)
Income			0.07	0.07
			(0.00)	(0.00)
Education			0.06	0.06
			(0.02)	(0.02)
Liberal			0.28	0.28
			(0.00)	(0.00)
Parent			−0.08	−0.08
			(0.20)	(0.21)
Mileage			−0.05	−0.05
			(0.04)	(0.03)
Age			−0.01	−0.01
			(0.01)	(0.01)
N	1623	1623	1572	1572
AIC	5781.46	5785.11	5290.06	5292.49

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In Model 2 we replace the *Any Costs* variable with separate dummy variables for each of the three adaptation costs treatments: higher electricity costs of an unspecified amount (*Electricity*), higher electricity costs estimated at $500 per household per year (*Electricity $500*), and higher electricity and food costs of unspecified amounts (*Electricity & Food*). We find that the two treatments that involve more specific adaptation costs—*Electricity* and *Electricity $500*—are marginally significant with p-values of 0.10 and 0.07, respectively. However, the *Electricity & Food* treatment has an effect that is far from any conventional significance thresholds. And we again find no significant effect of the *Ancillary Benefits* treatment.

In Models 3 and 4 we add covariates that account for various political and demographic characteristics that are likely to be associated with support for the gasoline tax. Here we find that controlling for these variables leads to an increase in the impact of most of the treatment groups; we find significant effects of the *Any Costs* ($p = 0.005$), *Electricity* ($p = 0.02$) and *Electricity $500* variables ($p = 0.004$), along with a marginally significant effect ($p = 0.10$) of the *Electricity & Food* manipulation. We again find no significant effect of the *Ancillary Benefits* treatment.

In Models 3 and 4 we operationalized political ideology by asking participants to indicate their conservative/liberal ideology on a seven-point scale. For the purposes of the regression analysis, we recoded the variable on a 0–6 scale such that higher numbers indicate more liberal ideologies. As one might expect, we find a highly statistically significant relationship between political liberalism and support for the gasoline tax (*Liberal*). This is consistent with the findings of other studies; for instance, Carrico et al. (2015) find that even self-identified conservatives will oppose a policy that they might otherwise have supported were it not to have been framed around climate change. In addition, Konisky et al. (2016) find that even the direct, lived experience of events that might be understood as evidence of a changing climate turns out to be only a very small driver of support for climate policy when compared to ideology.

The other covariates in Models 3 and 4 behave largely as expected. We find that people with higher levels of education, or with higher incomes, are willing to pay higher amounts—perhaps because gasoline costs represent a smaller portion of their family budgets.[15] We also find that people who are older (*Age*), or who report driving a greater number of miles each year (*Mileage*), are less willing to pay the gasoline tax. Interestingly, we find that men (*Male*) are more willing to pay the tax than women, although the difference is only marginally significant ($p = 0.06$). Meanwhile, we do not find any evidence to suggest an effect of parenthood; the results reveal no statistically significant difference between the respondents who answered "yes" and "no" to the question "Do you have any children?" (*Parent*).

In a series of interaction models presented in Table 1 of the supplementary information, we examine the possibility that the effect of providing information about adaptation costs might have effects that vary as a function of ideology (Model 5), education (Model 6), or income (Model 7). Although these models suggest that the expected impact of the experimental treatment is somewhat larger in cases where the respondents have a more liberal political ideology, are more highly educated, or have higher incomes, the difference in the size of the treatment effects over the range of each conditioning variable is not statistically significant.

Discussion and conclusions

The key finding to emerge from this study is that adaptation does not necessarily undermine mitigation; in fact, based on the results our experiment, it appears that providing information about adaptation costs modestly enhances support for mitigation. This is an intriguing result that future work should test in other experimental frameworks.

We recognize that adaptation, even in its expansive definition, is not a silver bullet and that it faces policy challenges as well (Adger et al., 2009; Dolšak & Prakash, 2018; Few, Brown, & Tompkins, 2007). While some actors that are vulnerable to the effects of global climate change may not be able to afford to invest in adaptation (Thomas & Twyman, 2005), this sort of fiscal mismatch can be

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addressed via appropriate subsidies and other types of redistributive policies. This approach is relevant both in the domestic sphere and at the regional/global level. For example, at the international level, the Global Environmental Facility, a partnership of 183 countries working with civil society, non-governmental organizations (NGOs), and the private sector to address environmental issues, is making adaptation funds available to developing countries. At the national level, modest assistance is available from the U.S. Environmental Protection Agency and the U.S. Federal Emergency Management Agency.

To be clear, we are not arguing for abandoning mitigation-based strategies. We are instead highlighting that a focus on adaptation need not undermine support for mitigation; rather it can enhance its support. This change of course is politically wise and practical. By creating local benefits, adaptation creates local constituencies that favor investments in climate change policies. Not only does adaptation deprive politicians of the "China excuse," it also creates new political coalitions to promote pro-environmental policies. As adaptation gathers steam, various groups will begin to recognize the costs of ignoring global climate change. Instead of crowding out mitigation, promoting adaptation may, over the long term, actually create the political support for more aggressive mitigation policies (Carrico et al., 2015).

The results of this study identify a number of areas for further research. While these results suggest that conveying information about adaptation does not necessarily undermine support for mitigation, further research should examine the causal pathways responsible for this outcome. One intriguing possibility is that that providing information about adaptation costs gives readers a greater sense of agency, and therefore makes them more likely to engage with the problem (Wibeck, 2014). The particular frames we used in this experiment implied that while adapting to climate change is likely to be costly and unpleasant, it is nonetheless possible. Yet at the same time, the stories suggested that these adaptation costs can be avoided by embracing a mitigation strategy. The respondents who read about adaptation costs were therefore presented with a choice between two unattractive options—paying now in the form of a gasoline tax, or paying later in the form of more costly adaptation costs—and for the most part they chose the one that was presumably less costly overall (the mitigation strategy).

Meanwhile, the respondents in the control condition were faced with a choice between paying for the mitigation efforts, or facing "an environmental catastrophe in the years to come." It is possible that this frame triggered feelings of fear and resignation on the part of the respondents, which in turn depressed their willingness to pay for the gasoline tax. This would be consistent with the fact that a large number of studies have found that discussing climate change using fear-inducing language or images often fails to motivate respondents to act, perhaps because doing so invokes psychological defense mechanisms such as apathy or denial (Moser & Dilling, 2011; O'Neill & Nicholson-Cole, 2009; Wibeck, 2014). While it would be useful to run a similar experiment using a control group that is less likely to be fear-inducing, it is also worth considering whether the very act of discussing possible adaptation costs goes some way towards counteracting the fear that is likely to be triggered by any realistic depiction of the consequences of climate-change. By discussing adaptation costs, we are signaling that while climate change is certainly undesirable, it can still be survivable. And if it's survivable, then it's worth considering how to make the problem more manageable.

Further research should try to examine the possibility of a link between providing information about adaptation scenarios and feelings of individual agency. For instance, qualitative research using focus groups could explore individual reactions in more detail. In doing so, it could ask whether providing information about adaptation measures does in fact cause people to become more aware of the problems posed by global warming, as the "risk salience" hypothesis suggests, and if, at the same time, it causes people to feel more motivated to act. Another useful extension would involve testing whether the respondents' apparent willingness to support climate change mitigation efforts translates into actual behavior—for instance, by inviting the respondents to donate part of their survey incentive towards the purchase of carbon offsets.

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Moreover, further research ought to consider whether the impact of conveying information about adaptation costs differs as function of the mitigation policy under consideration, and the extent to which this varies across national contexts. For example, we might find that while the US public tends to be strongly opposed to any new taxes, they may be more or less responsive to manipulations involving proposed cap-and-trade schemes (Goulder & Schein, 2013). Citizens of other countries, however, might be more receptive to proposals such as a gasoline tax, in which case we might find that the relationship between adaptation and mitigation takes on a different dynamic.

Notes

1. See Burniaux and Martins (2012).
2. Some suggest that US should not bear the burden of climate mitigation because China, the biggest current emitter of greenhouse gases, has not committed to mandatory emission reductions. This is because American reductions will be offset by increases in emissions by China and the American sacrifice will be in vain. Thus, the "China excuse" coheres with social cognition theory which suggests that individuals are less willing to contribute to collective endeavors such as climate mitigation if they believe that their efforts will not impact the collective outcome (Bandura, 1986).
3. In recent years, Amazon's Mechanical Turk ("MTurk") has emerged as a popular method of undertaking surveys of political opinion. Carrico et al. (2015) also use MTurk in their study examining support for climate change mitigation. While the external validity of experiments performed in a laboratory setting or using web-based samples is limited in many ways (as discussed extensively by Levitt and List (2007)), we believe that the behavior of individuals revealed in these contexts can be used as a basis for understanding and analyzing key factors that underlie policy choices as reflected in recently published experimental work (Evans et al., 2014; Howell et al., 2016). Moreover, a number of recent studies have attempted to benchmark the results of MTurk surveys against other survey pools that are commonly used in social science research. Although MTurk respondents tend to be younger, more educated, and more liberal than the population as a whole, the results of these exercises allay many of the concerns that have been raised about both the external validity and quality of data obtained of MTurk samples (see Buhrmester, Kwang, & Gosling, 2011; Mason & Suri, 2012; Sprouse, 2011; Berinsky et al., 2012; Huff & Tingley, 2015).
4. When designing the experiment, we were primarily interested in the contrast between what we see as the conventional argument for climate change mitigation—i.e., one that suggests that failing to act will result in a potentially catastrophic outcome—and a more nuanced argument that alerts the reader to the possibility of adaptation. However, it would be interesting for future researchers to consider how the impact of each of these frames compares to the baseline level of support found among individuals who have not been exposed to any information about climate change.
5. As per the Energy Information Agency, the average annual electricity bill for a US household is about $1,369 (http://www.eia.gov/electricity/sales_revenue_price/pdf/table5_a.pdf). $500, therefore, represents a rise in the average electricity bill of about one third.
6. On the use of surveys for contingent valuation of public goods, see Mitchell and Carson (1989).
7. In their study of the willingness of consumers to pay extra for gasoline containing cellulosic ethanol, Solomon and Johnson (2009, p. 2139) used a similar format of payment card in which the respondents were presented with a number of discrete choices ranging from a minimum of 0 cents per gallon to a maximum of >$1 per gallon.
8. The estimated consumption of 500 gallons of fuel used in the survey was a loose approximation based upon the more precise estimate of 583 gallons per driver derived by Sivak (2015).
9. Please see the supplementary information for further details of the exclusion conditions.
10. As far as we are aware, this is larger than the sample sizes used among currently published experimental work examining the relationship between support for mitigation and adaptation. Carrico et al. (2015) reports findings based on 1,190 valid responses in the U.S., Evans et al. (2014) on 103 respondents in New Zealand, and Howell et al. (2016) on 800 participants in the U.K.
11. According to a recent Gallup poll, 42% Americans identify as independents, 29% as Democrats, and 26% as Republicans (Jones 2016). While the MTurk sample does not match the national levels in self-identified partisanship, this does not pose a problem for us because we also consider the impact of the treatment at varying points along the political ideology scale.
12. At that point in time, the average price for a regular gallon of gasoline in the US was $2.17. An additional tax of 20 cents per gallon therefore represented a price increase of around 9%.
13. For instance, 32% of respondents were willing to pay 20 cents per gallon or more when told that electricity costs are likely to rise by $500 per year, whereas only 29% were willing to do so when the dollar amount of the

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additional electricity costs was left unspecified. However, these differences are not statistically significant (z=1.00; p=0.32).

14. We chose an ordered probit model due to the fact that our dependent variable, the respondents' willingness to support the policy, has an unbounded upper limit of greater than 80 cents per gallon. However, when we re-estimated the models in an ordinary least squares (OLS) framework by replacing the "greater than 80 cents per gallon" with values between 85-120 cents, the main findings continue to hold.
15. We also estimated a model in which we interacted the income variable with the *Any Costs* indicator. As one might expect, the results suggest that the impact of the manipulation is somewhat larger among individuals with higher incomes (see Model 7 in the supplementary information).

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