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Beliefs, politics, and environmental policy

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Beliefs, politics, and environmental policy.

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Abstract

The public often perceives environmental problems differently from the experts who study them. The regulatory response to these problems also often does not coincide with experts' recommendations. These two facts are mutually consistent – it is unlikely that regulations based on factual claims that are substantially different from voters' opinions would be political feasible. Given that the public's beliefs constrain policy choices, it is vital to understand how they come about, whether they will be biased, and how the inevitable heterogeneity in people's beliefs filters through the political system to affect policy. We survey recent theoretical and empirical work on individual inference, social learning, and the supply of information by the media, and identify the potential for biased beliefs to arise. We then examine the interaction between beliefs and politics. We ask whether national elections and votes in legislatures can be expected to result in accurate collective decisions, how heterogeneous beliefs may induce strategic political actors to alter their policy choices, and how

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persuasion by experts and lobbies affects the information at policy-makers' disposal. We conclude by suggesting that the relationship between beliefs and policy choices is a relatively neglected aspect of the theory of environmental regulation, and a fruitful area for further research.

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Introduction

Many of us who work on environmental problems will have experienced the difficulty of conveying their importance to non-specialists. Perhaps we have found ourselves defending the robustness of climate science to a contrarian uncle, or extolling the importance of biodiversity to a dubious aunt. Our relations and friends are often educated people, skilled in their own professions, who have formed strong opinions about the science underlying environmental problems, their potential consequences in their own lives, and the appropriate policy response to them. If pushed they will present arguments to support their views, which often draw on their exposure to the media, and the opinions of friends, public commentators, and religious or secular authority figures.

Many of us will also have experienced another common response to environmental issues: indifference. Surveys of public opinion show a low level of concern about environmental problems. The International Social Survey Program, a project of the independent research organization NORC at the University of Chicago, found that 3.6% of Americans ranked the environment as their chief policy concern, behind the economy (25%), health care (22.2%), education (16%), poverty (11.6%), and crime (8.6%) (Smith, 2013). Moreover, people's beliefs about specific environmental problems are often heterogeneous, and not stable over time. The proportion of Americans who believe that the global climate has been warming over the past few decades has fluctuated from a high of 78% in July 2006, to a low of 57%

in October 2009 (Shapiro, 2014). Between 50% (in 2010) and 61% (in 2003 and 2007) of Americans believe that any perceived warming is due to human activity (Saad, 2013). These large swings in public opinion have occurred despite no comparable fluctuations in our basic scientific understanding of climate change.

The beliefs of Joe Public, who generally has a visceral interest in the size and constituents of his tax bill, are ground zero for the battle to implement environmental policies. Politicians are unlikely to be able to support policy choices that conflict with the worldview adhered to by a majority of their constituents. In addition, the political class is overwhelmingly drawn from the ranks of the lay public.[1] Most politicians are not research scientists, and while they may have access to more information than the average newspaper reader, their opinions on environmental issues are shaped by many of the same forces that determine the beliefs of the average member of the public.

Environmental economics has historically given little attention to the question of how the public arrives at its beliefs about environmental problems, whether social forces and democratic institutions aggregate information in an efficient manner, and what the consequences of belief heterogeneity are for the policy process. In this paper we argue that the process of social belief formation, and its consequences for the political economy of environmental policy, should be an integral part of the positive study of environmental regulation. The issues raised by this line of enquiry are in a sense *prior* to many of the questions we have traditionally concerned ourselves with. Whereas most economic analysis takes the level of demand for regulation of environmental externalities for granted, we ask: how does demand for intervention arise? Will this demand, and the policies it ultimately gives rise to, reflect accurate knowledge about environmental risks, or can we expect systematic under or over-regulation of environmental externalities? A rich literature in political economics and social learning has recently emerged, yielding important insights into these questions. Our aim is to provide a selective overview of this literature, and show its relevance for understanding *how beliefs might influence* environmental policy

[1] Of the 535 members of the 114th US Congress, only three listed previous occupations in the natural sciences. By comparison, 273 listed business, and 202 law (Manning, 2015).

choices.

Several excellent review papers have studied the political dimensions of environmental regulation. Oates & Portney (2003) provide possibly the best coverage of the literature. They survey both theoretical and empirical studies of the regulatory process, and highlight the role of special interests, and the consequences of environmental federalism, for policy choice. Hahn & Stavins (1992) survey political obstacles to the implementation of market-based instruments, and Anthoff & Hahn (2010) examine inefficiencies in extant environmental regulations. Similarly, Keohane et al. (1998) investigate why the practice of policy selection diverges from the normative first-best. Detailed case studies of specific regulations include Stavins (1998), Joskow & Schmalensee (1998) and Ellerman et al. (2000), who examine the political economy of the US Acid Rain program, and Hahn (2009) and Ellerman & Buchner (2007), who study regulation of greenhouse gases. Our approach, while related to the issues raised by these authors, is both narrower and more conceptual in nature. We are concerned exclusively with the informational aspects of the positive theory of environmental regulation – how are beliefs formed, and how do political institutions aggregate them? Our survey of the literature will show that, while progress has been made on understanding the mechanisms that influence public beliefs and policy choices, a great deal more needs to be done to provide a satisfactory answer to this question.

The paper is structured as follows. We begin by discussing characteristics of global environmental problems that make them particularly susceptible to misunderstanding. We then discuss the mechanisms of belief formation. On the demand side we consider the processes of individual inference and social learning, and on the supply side we consider the role of the media. Each of these mechanisms can introduce biases or errors into beliefs, both individually and collectively. Finally, we ask how the political process might moderate or exacerbate biases in beliefs. We end by highlighting key questions for future research.

(Mis)understanding global environmental problems

Many global environmental problems have characteristics that make them difficult to understand.[2] A primary reason for this is that very few of us have first-hand sensory experience of their consequences (Weber & Stern, 2011; Myers et al., 2013). Consider the following issues, which would certainly make it onto any environmentalist's list of concerns: climate change, biodiversity loss, and the decline in world fisheries. How many of us have actually 'seen' any of these problems with our own eyes? They are not localized events, but rather long-run trends, or slow changes in the distribution of events, and thus removed from our experience. Compare this to the immediacy of an oil spill, whose consequences are easy to capture emotively on film. Oil spills are also immediately detectable. This is in stark contrast to our three global problems, each of which plays out over a long time scale, on the order of a human lifetime. There is a long lag between damaging actions and their consequences. This requires one to think abstractly, and project the consequences of current behaviors into the distant future in order to appreciate the magnitude of these problems.

A further advantage of oil spills and other industrial accidents in the competition for public concern is that they are causally 'focused': a small number of parties (e.g. the rig or tanker operators and their parent company) does harm to innocent bystanders. The major environmental problems we listed above are all causally 'diffuse' – they arise from the cumulative actions of many parties (not least ourselves), and we are all affected. There is no clear victim and no clear villain.

Understanding the consequences of global environmental problems also often requires one to follow long chains of causal reasoning. Their effects on the things most people care about are indirect, rather than direct. Consider the following example: industrial toxins and pesticides have been shown to reduce the size of bee populations, which in turn affect

[2] Of course many other issues, e.g. fiscal policy, are also difficult to understand. We do not claim that global environmental problems are unique in this regard, but we conjecture that they are *especially* poorly understood, relative to our level of scientific knowledge, for the reasons outlined below.

pollination rates, crop yields, and ultimately food prices. What most of us care about is the price of food, and not bees, but we need to understand the role of bees in the food production process in order to appreciate how industrial activity may be affecting our budgets. Similarly involved chains of reasoning are required to understand how current greenhouse gas emissions may increase future political conflicts (Hsiang et al., 2011), or how reduced biodiversity may make us more vulnerable to infectious diseases (Keesing et al., 2010).

The upshot of these characteristics – remoteness from first-hand experience, slow changes in trends and distributions of events, causal diffusivity, and logical complexity – is that many of the major environmental problems require considerable cognitive effort to understand. Few people invest the necessary time to absorb all this complexity, as the costs of becoming informed far outweigh their potential benefits at the ballot box (Downs, 1957). A large literature on risk perception and the public understanding of science lends empirical credence to this claim. Bostrom et al. (1994), Read et al. (1994), and Reynolds et al. (2010) document a series of public misunderstandings about the science and causes of climate change, including a widespread confusion between weather and climate which points to the difficulty in conceptualizing changes in trends and distributions. A recent study by Herrnstadt & Muehlegger (2014) shows that internet searches for "climate change" and "global warming" increase when the weather is unusually warm, and even that members of the US congress are more likely to vote for pro-environment measures when their home state recently experienced unusual weather. Voters thus overweight the significance of short run fluctuations in local weather patterns when forming their beliefs about climate change (see also Zaval et al., 2014). Moreover, this change in voters' perceptions may play a role in the legislative process.

The fact that people may not understand environmental problems does not necessarily imply that their overall perceptions of their severity are inaccurate, or that society will reach regulatory decisions based on misguided beliefs. Even though people may not fully grasp the

conceptual basis for concern, they could nevertheless arrive at broadly accurate beliefs about the importance of these problems by aggregating disparate information sources. This could occur at the level of the individual, or for society as a whole. In order to investigate whether this is likely to happen we need to examine both belief formation processes themselves, and the 'rules of the game' that determine how beliefs influence policy choices.

Why do we believe what we believe?

In this section we discuss three factors that work to determine the public's beliefs: individual inference, social learning, and the media. The first factor – individual inference – determines how our beliefs are updated by signals from the media, peers, or nature itself. We discuss both rational and behavioral models of inference, and identify the potential for biased individual beliefs to arise. Social learning relates to how the interactions between groups of people affect beliefs. We examine whether social interactions can be expected to lead to collectively accurate beliefs. Finally, we ask how the media shapes the public's informational landscape.

Individual inference

The classical economic model of belief formation assumes that economic agents process new information in a Bayesian fashion. In the Bayesian model agents have some subjective probabilistic beliefs about which of a set of hypotheses is likely to be true. With each new observation of an informative 'signal', these beliefs are updated in accordance with Bayes' rule (e.g. Jaynes, 2003). For example, an observation of a snow-free Northern winter might cause a Bayesian agent to increase her subjective probability on the hypothesis 'Climate change is real', and decrease her subjective probability on the hypothesis 'Climate change is not real'. This would happen only if the agent believes snow-free winters are more likely in a world where

climate change is real than they are in a world where it is not. [3]

Bayesian learning has many attractive normative properties. One of its implications is that, after enough observations, all heterogeneity in people's prior beliefs will be washed away, and everyone will hold the same beliefs (Blackwell & Dubins, 1962). Moreover, if one of the hypotheses that agents evaluate happens to be correct, people's beliefs will eventually converge to the truth (Doob, 1948). [4]

This sanguine view of belief formation dominates much economic modeling. Nevertheless, there is reason to doubt the descriptive power of Bayes' rule. The psychologists Daniel Kahneman and Amos Tversky have identified a slew of biases in human judgment under uncertainty (Kahneman et al., 1982). Many of them have a bearing on the belief formation process, but we single out a few that seem especially relevant.

The first set of biases leads people to overreact to information. Base-rate neglect (Kahneman & Tversky, 1973), suggests that most people do not obey Bayes' rule when reasoning about conditional probabilities. For example, the philosopher Michael Sandel has observed that a high proportion of Harvard students are the first-born children in their families, and uses this data to suggest that first-borns are more likely to go to Harvard than their siblings (Millner & Calel, 2012). This argument neglects the 'base rate' of being born first: a child picked at random is more likely to be first born than to have any other rank in the birth order. People

[3] Exactly how much beliefs change depends on how 'informative' an observation is, in a manner made precise by Bayes' rule. If the chance of observing a snow free winter is much higher if climate change is real than if it is not, an observation of a snow free winter will cause the agent to place a lot of weight on the 'climate change is real' hypothesis. If the chance of observing a snow free winter is the same regardless of whether the climate is changing, the observation is uninformative, and beliefs will not change.

[4] The theoretical results on the efficiency of Bayesian learning need to be interpreted with care. They hold only in the long run, after agents have seen a great deal of data. In the short run, people may place a lot of weight on incorrect hypotheses, and exposure to new data may even *increase* the polarization in a group's beliefs (Dixit & Weibull, 2007). Acemoglu et al. (2008) also show that if agents are even a little uncertain about the likelihood of observing a given signal, conditional on an hypothesis, their beliefs can remain divergent, *even in the long run*.

subject to base-rate neglect overreact to new information, since their inferences are not moderated by prior beliefs. Probability neglect is another common behavioural bias: people's willingness to pay to avoid emotionally impactful events such as nuclear disasters is not sensitive to the likelihood of the event occurring (Sunstein & Zeckhauser, 2011). This is a form of overreaction, as assessments of the severity of an issue are not moderated by the likelihood of its occurrence. Conversely, the availability heuristic suggests that people's estimates of the risk of a given activity are overly sensitive to rare high-impact events (Tversky & Kahneman, 1973). For example, lay estimates of the risks of air travel are likely to be overly sensitive to infrequent airline disasters. Viscusi (1998) comprehensively documents how these biases distort the public's perceptions of the risks of accidents, diseases, and environmental contamination.

A second set of biases leads people to respond to new information differently depending on whether it conflicts with their prior beliefs or their values. This may lead to either under- or overreaction to new information. Confirmation bias is perhaps the best known of these phenomena: people tend to overweight information that confirms their prior beliefs, and underweight information that conflicts with them (Nickerson, 1998). Rabin & Schrag (1999) show that this tendency leads to overconfidence (people believe in their favored hypothesis more strongly than they should), and that false beliefs can persist even after exposure to an infinite amount of information. A diverse literature also suggests that people's interpretation of information is influenced by their values. Such 'motivated reasoning' (Kunda, 1990), so-called as beliefs are constructed to fulfill a desire or support an identity, are likely to play an important role in explaining public attitudes to global environmental problems, as they are highly emotive issues. For example, Kahan et. al. (2011) show that people's perceptions of the degree of scientific consensus on global warming are strongly correlated with their political values.

Finally, if we are not over- or underreacting to information, we may simply not be paying attention to all the information at our disposal. Our worlds are increasingly informationally

complex, and we often do not have the mental capacity to give every new datum its due. A diverse experimental literature in psychology and economics confirms that 'attention is a limited resource' (Dellavigna, 2009). This idea is sometimes known as the 'finite pool of worry' hypothesis in environmental psychology, where it has been used as a partial explanatory factor for many peoples' lack of concern about global climate change (Weber, 2006).

Given the prevalence of these biases in belief formation, there are many reasons to doubt that individuals will arrive at accurate assessments of environmental risks on their own, even if their informational inputs are unbiased. Accepting that individuals' beliefs are subject to biases, we now ask whether groups can do better on aggregate than individuals.

Social Learning

Human beings are social animals – our social and family ties largely determine our informational environment. Most of us inherit our political and religious values from our parents, and we are more likely to make new social connections with those who share our attitudes and beliefs, a phenomenon known as homophily (McPherson et al., 2001). This point of view is summed up by North (2010): "Much of what passes for rational choice is not so much individual cogitation as the embeddedness of the thought process in the larger social and institutional context." The question is, will the social aggregate reach better judgments than its constituent parts?

Recent popular books, including "The Wisdom of Crowds" (Surowiecki, 2004), and "The Difference" (Page, 2007), put forward the optimistic view that collectives have more accurate beliefs on average, and make better decisions, than individuals. The theoretical structure that underpins this view originates with the French political theorist Marquis de Condorcet, and the English polymath Francis Galton. To take Galton's example, suppose that a group of people is trying to guess the weight of a cow at a livestock fair. Each person submits a guess, and the closest guess wins the cow. The law of large numbers implies that so long as

people's guesses do not share common biases, and are statistically independent, the mean guess will be an increasingly accurate predictor of the cow's weight as the number of guesses increases. Results of this kind (there are several versions) are known as Condorcet Jury Theorems (CJTs). They have been argued to legitimate the very idea of democracy (List & Goodin, 2001).

The CJT makes several assumptions – peoples' information is statistically independent, they don't share biases, and they are assumed to reveal their information truthfully and simultaneously, and not to engage in strategic thinking. The sanguine results of the theorem are overturned when these assumptions are relaxed. Let's consider the assumption of statistical independence of information first. In reality, people's beliefs are very often determined by their social environment – they communicate with their friends and families, and their beliefs may in fact reflect some aggregate of the information they glean from these social interactions. Rather than being statistically independent, everyone's beliefs depend on the beliefs of everyone else! How will this communication and dependence between people affect the accuracy of the group's beliefs?

Golub & Jackson (2010) study this question by extending a classic model of social learning on networks due to DeGroot (1974). All agents in a social network receive an independent signal about an event, and then each individual communicates with its neighbors and updates its beliefs by forming a weighted sum of their neighbors' information. One can then ask whether the group's beliefs will converge to the truth. The results are illuminating: if the 'influence' of each agent goes to zero as the size of the network grows, then the group will converge on true beliefs. Influence here is a measure of how important an agent's initial beliefs are in determining everyone's final beliefs, so the condition is effectively that no single agent can be an opinion leader as the size of the network grows. Golub & Jackson (2010) relate this condition to the structure of the social network that the agents inhabit. If this condition fails, the group can get stuck with false beliefs.

It is also worth examining what happens when agents' actions are not non-strategic and simultaneous, as assumed in the CJT. Consider a simplified version of Galton's cow weight guessing game, in which the cow can have two weights ('High' and 'Low'), and agents receive idiosyncratic informative signals about whether the cow has high or low weight. Suppose that agents now reveal their guesses sequentially, instead of simultaneously. Whenever an agent's turn to guess arrives she has access to the history of past guesses, and will make the best guess she can, given her idiosyncratic signal, and the observed sequence of guesses by others. Versions of this setup have been studied in Bikhchandani et al. (1992) and Banerjee (1992). They show that a strong form of path dependence occurs in this situation. Fully rational agents find it optimal to neglect their private signals, and simply copy the guesses of those who have gone before them, an effect known as herding. Chamley (2004) contains a comprehensive treatment of herding phenomena with applications to many areas of economics. Once again, probing the assumptions of the default model of social belief aggregation leads us to reject its optimistic findings.

Behavioral evidence highlights further biases due to group interactions. Eyster and Rabin (2010) study a behavioral variation on the herding phenomenon. In their setup agents account for the fact that their predecessors' choices reflect their private information, but neglect that these choices will themselves be based on inferences from the actions of even earlier agents. This results in 'naïve herding': agents can become extremely confident in incorrect beliefs, to the point where they would have been better off if they had not observed anyone else's choices.

A related effect, known as group polarization, also investigates how imperfect inference about the actions of others distorts social beliefs. An experimental study by Schkade et al. (2007) demonstrates the phenomenon. Two groups of subjects were selected, one from Boulder, Colorado (a liberal town), and the other from Colorado Springs (a conservative town). The subjects were asked to discuss contentious political issues, including climate change, affirmative action, and same-sex partnerships. The study found that the groups' beliefs about these issues became more extreme after deliberation – liberals become more liberal, and conservatives more conservative. Glaeser & Sunstein (2009) point out that greater confidence and polarization occurs even when very little new information is learned from the deliberation process. They thus suggest that people are 'credulous Bayesians', who treat each member of

the group's contributions as if it were a truthful revelation of an independent private signal. People thus insufficiently adjust for the fact that information sources in the group are dependent, that the group may not be a representative sample of the population, and that people may strategically manipulate the messages they send to the group. This phenomenon is also known as correlation neglect (Ortoleva & Snowberg, 2015).

The media

The previous two sections examined how individuals and groups respond to informational inputs. In this section we consider the supply side of the information market – the media – and ask whether it is likely to provide an accurate picture of environmental risks. The media are subject to economic incentives, competitive pressures, and norms of best practice, all of which influence which information they report, and how they report it. Since most peoples' beliefs about environmental risks are informed by the media, it is vital to ask how these forces might affect the quality of the information they provide.

There can be no question that the media has a big impact on people's beliefs and the political process.[5] Do they provide an accurate picture of scientific knowledge on environmental issues? Economists have studied how supply driven biases in reporting may arise in models of media capture by governments or special interests (Besley & Prat, 2006), and of the economic incentives and ideological preferences of journalists (Baron, 2006). Both of these effects can be shown to lead to persistent biases in coverage. Competition in media markets can however help to alleviate these problems (Gentzkow & Shapiro, 2008). Competition between media firms makes it more difficult for vested interests to suppress stories (they need to buy off many firms simultaneously), and gives firms incentives to invest in news quality, thus increasing the costs of bias. On the other hand, Cagé (2014) finds that an increase in the number of newspapers could decrease the quality and quantity of news provided. The more competitive the news market is, the greater the media's

[5] See Gentzkow et. al. (2014), DellaVigna & Gentzkow (2010), and Prat & Stromberg (2013) for reviews of the political economic literature on media influence. Empirical examples abound, e.g. the level of Indian state governments' response to local food crises is related to local newspaper circulation figures (Besley & Burgess, 2001), and newsworthy events such as the Olympics crowd out media coverage of natural disasters, and hence actual government relief efforts (Eisensee & Strömberg, 2007).

incentives to entertain, rather than inform. In addition to these purely economic motivations, the norm of journalistic balance may lead to slanted coverage of environmental issues. Boykoff & Boykoff (2004) demonstrate that the deployment of this norm in US print media from 1988 to 2002 led to a misrepresentation of the scientific consensus on climate change, which in turn gave rise to a disconnect between popular opinion and the state of scientific knowledge.

The demand side of the media market may induce its own distortions. These arise from the behavioral biases we discussed above. For example, confirmation bias – the fact that people prefer to receive information that confirms their prior beliefs – has been observed directly in news markets (Gentzkow & Shapiro, 2010). The implications of confirmation bias for media markets have been studied by Mullainathan & Shleifer (2005). They show that if consumers prefer to hear news that confirms their prior beleifs, and have diverse beliefs about a given topic, competitive media firms will slant their coverage towards extreme positions. More optimistically, if the number of market participants in their model is very large, it is possible that even though individual outlets are biased, an individual who reads all sources may nevertheless be able to piece together accurate information. Given that most people consume a small sample of media however, it seems unlikely that individuals will receive accurate information about complex environmental problems.

Gentzkow & Shapiro (2006) consider a related model of demand-driven media bias, and show that even rational Bayesian consumers will believe that information that confirms their prior beliefs is of high quality. Thus the media have incentives to pander to the beliefs of consumers, in order to demonstrate their quality. Gentzkow & Shapiro (2006) show that the existence of a source that provides a concrete ex post verification of the veracity of a reported story can ameliorate media bias, but emphasize that this is much more likely to occur for short-run events (sports outcomes, weather forecasts), than complex long-run issues such as global environmental problems.

Thus, although competitive media markets provide some checks on bias for some issues, it seems unlikely that these checks will be effective at ruling out informational distortions for

complex environmental problems. Since the media play such an important part in deciding who gets elected, and which policies governments are likely to implement, this is a telling finding.

Beliefs and Politics

The previous section highlighted the facts that a) individuals are unlikely to process the information they receive in a Bayesian manner, b) group interactions can reinforce individual biases, and c) the media that supply information are themselves subject to bias. These biases only matter if they translate into inadequate policy choices. In order to understand how this might occur, we need to understand how public decision-making is affected by the distribution of beliefs in society.

Beliefs influence policy through many channels in modern democracies. We first investigate how the public's beliefs might be represented by the outcomes of competitive elections: how are political parties' electoral platforms related to the distribution of people's beliefs?[6] Elections are however only one element of democratic decision-making. We usually delegate decision-making power to our elected representatives, and their beliefs and political incentives will have a major impact on which policies are implemented. We examine these incentives next, focusing on whether policy choices by parliaments and congress are likely to aggregate information efficiently, and on governments' incentives to distort policy choices because of the heterogeneity in voters' beliefs. Finally, we examine the supply side of the information market in the political process – experts and lobbies. Politicians are influenced by these persuasive actors, and we ask whether competition between opposing viewpoints is likely to result in unbiased and efficient information provision to policy-makers.

[6]Our treatment of this complex issue will of necessity be brief and selective. For a full-throated defense of the efficiency of democratic institutions see Wittman (1995), and for an equally emphatic denial of their efficiency see Caplan (2008).

Belief aggregation in elections

One of the advantages of democratic systems of government over more autocratic alternatives is that they provide a mechanism for bringing information that is dispersed across the population into the political process. The argument goes that the since the public knows more about how a policy will affect them than distant government officials, centralized decision-making is informationally inefficient (Hayek, 1945). People's votes thus carry valuable information about their preferences over public policies, and elections provide a means for collecting it. But how exactly are people's beliefs represented by electoral outcomes?

The median voter theorem (Black, 1948; Downs, 1957), provides a 'base case' model of how preferences and beliefs might be aggregated in elections. Suppose beliefs about the severity of an environmental problem can be mapped into preferences over a one-dimensional policy variable (e.g. the level of a carbon tax), people's preferences over this variable are 'single peaked'[7], and that two office-seeking parties compete to win a majoritarian election over which policy to implement. The theorem states that the unique equilibrium of this electoral game is for both parties to announce that they will implement the ideal policy of the median voter.[8] Thus, in the case of a carbon tax, both candidates would propose a policy for which exactly half the population would prefer a higher tax, and exactly half the population would prefer a lower tax.

Let us take the median voter result at face value for the moment and ask what it means for the belief aggregation properties of elections. The result provides an optimistic view of the ability of elections to balance out opposing extreme viewpoints. So long as there are equal numbers of people with opposing biases (some exaggerating and some underestimating environmental risks), their beliefs will have no effect on the electoral outcome. If however there is a tendency for biases to be more likely in one direction – for example with more people being likely to underestimate risks than to overestimate them – the median voters'

[7] Individuals have single peaked preferences if they have a most preferred policy – their bliss point – and for any two policies that are both above (or below) their bliss point, the one that is closer to the bliss point is preferred.

[8] This result also requires voters to believe that parties will carry out their electoral commitments.

policy preferences will also be biased. Thus the median voter theorem provides only a partial antidote to voter bias – we need biases to be symmetrically distributed if they are to cancel out. This symmetry assumption is strong. Voluminous behavioral evidence, some of which we have discussed above, suggests that people are prone to common biases in assessing and understanding environmental risks (Margolis, 1996; Weber & Stern, 2011).

It would be a mistake however to believe that there is a simple relationship between the degree of voter bias and the quality of electoral outcomes. In order to study how voters' beliefs and biases map into electoral outcomes more explicitly our model of voters' preferences must be enriched. In the standard setup of the median voter result voters' preferences are inert, and as such, we cannot say whether the heterogeneity in their preferences derives from differing ideologies, differing beliefs, or both. In order to separate tastes from beliefs, voters' preferences need to be extended to depend on a 'state of the world'. For example, a voter might prefer a higher carbon tax if climate change is a serious problem, and a lower tax if it's not. Voter's beliefs about the state of the world are explicit determinants of parties' electoral incentives in such models, and can be separated from their political ideologies. Levy & Razin (2014) deploy a model of this kind to analyze how biases in voters' information processing may influence information aggregation in elections. Surprisingly, they show that elections can aggregate information more effectively, and lead to better policy choices, when voters are subject to correlation neglect than when they are strict Bayesians. This occurs because biased voters overreact to information, making their policy preferences depend more on their information, and less on their ideological preferences. This can be beneficial to society if voters' ideological preferences are sufficiently at odds with optimal policy choices. Ashworth & Bueno de Mequista (2014) also emphasize that if we are to understand how behavioral biases affect democracy's epistemic performance, we must understand how they affect the behavior of strategic political parties.

Political parties also often possess information of their own about the benefits of policies. A

growing literature examines how electoral outcomes reveal parties' private information, given that voters' beliefs about which policies are best depend in part on the information revealed by parties' platform choices. In a two-party binary policy model, Heidhues & Lagerlöf (2003) showed that office-motivated parties will not propose policies that reflect their private information, but rather choose platforms that pander to the electorate's beliefs. A recent paper by Kartik et. al. (2014) substantially generalizes and refines their results. In their model parties are free to choose platforms in a one dimensional policy space, and pandering is not an equilibrium. In fact they show that there is an equilibrium in which parties choose platforms that are *more* extreme than justified by their private information – they *anti*-pander. Moreover, they show that in any equilibrium of the signaling game between voters and parties, voters are no better off than they would be if they neglected the information of one of the parties. Office-seeking behavior by political parties can thus gives rise to a substantial loss of information in equilibrium.

The findings of these studies present a mixed picture of the ability of elections to aggregate information (either voters' or parties') about which policies will 'work'. In reality however, except in occasional referenda and ballot propositions, people rarely vote directly on policies. They vote for representatives to a legislative body who then decide on policies on their behalf. Representatives are constrained by their constituents' beliefs and preferences if they wish to be reelected, but they are also subject to their own political objectives or those of their parties, and they may act strategically in order to further these goals. We now ask how political outcomes might be affected by such behavior.

Strategy and information in legislatures and governments

Strategic voting in legislatures

Consider a very simple model of a legislative assembly voting on an environmental policy

initiative. Each member has its own beliefs about whether the policy is harmful or beneficial to the nation, and they simply vote 'yea' or 'nay' on the policy. For the sake of simplicity, assume (optimistically) that everyone has the same beneficent objectives, i.e. they want to vote 'yea' if the policy is in fact beneficial, and 'nay' if it's harmful, but they differ in their beliefs about its consequences. Will the legislature make the right choice about whether to implement the policy?

We have already seen one argument that suggests that in fact bodies of individuals with heterogeneous beliefs will make more accurate choices on average than any single individual – this is the content of the CJT we discussed above. We noted however that strategic behavior could alter the conclusions of the CJT if votes are cast sequentially rather than simultaneously. This may be less of a concern for votes on bills in parliament or congress, which are often as good as simultaneous. Nevertheless, strategic behavior can strongly influence electoral outcomes even in simultaneous voting contexts. Austen-Smith & Banks (1996) demonstrate that even if everyone has the same objectives, truthful revelation of private information by all voters in a majority rule contest is not necessarily an equilibrium outcome. They go so far as to show that accounting for strategic behavior can in fact make decisions made by a group under majority rule *less* accurate than simply allowing a single individual to decide, thus overturning the CJT results.[9]

A further feature of information aggregation in legislative bodies, which we have not yet captured, is the ability of representatives to abstain from voting on policy initiatives. The option to simply remove one's opinion from the policy decision clearly has consequences for information aggregation. Feddersen & Pesendorfer (1996) show that when representatives are informed to different degrees, those who believe themselves to be less informed than others will strategically abstain from voting on policy measures. The intuition for this is that strategic representatives realize that their vote will only matter if it is 'pivotal', i.e. it tips the vote one way or the other. A representative who believes herself to be comparatively uninformed

[9] A partial antidote to this conclusion is provided by Feddersen & Pesendorfer (1997) who show that in the limit as the number of voters tends to infinity, elections will again aggregate information efficiently even if voters behave strategically. Thus this discussion is more relevant for understanding the behavior of legislative bodies than for national elections with very large numbers of participants.

would thus prefer to abstain and let the vote be determined by her more informed colleagues rather than have a tie broken by her own poorly informed vote – this is known as the swing voter's curse.[10] While it may sound like a good thing to exclude less informed opinions, this is not necessarily the case. Representatives with well thought out beliefs, who nevertheless are more uncertain about policy consequences than their more confident peers, may choose to abstain. Strategic abstention thus moderates the effectiveness of voting as an information aggregation mechanism.

These examples illustrate that, even assuming that elected representatives act in the common good, strategic behavior can disturb the information aggregation properties of the CJT. We cannot expect the decisions legislative bodies take to be accurate, or to fully aggregate all the information that representatives possess. This conclusion is not based solely on theoretical models – an empirical literature suggests that people do indeed act strategically when voting on outcomes (Guarnaschelli et al., 2000; Battaglini et al., 2010).

Strategic policy selection by political parties

Until now we have assumed that the policies legislatures vote on are exogenously given. In general however, policy proposals are endogenous outcomes of the political process, and are thus subject to strategic effects and informational distortions. This is especially true of 'long-run' policy issues, such as our global environmental problems. Long-run policy making in democracies requires incumbents to deal with a time-inconsistency problem: a party with different beliefs or values may supplant them in the future. This lack of control over future policy choices gives current governments a strategic incentive to choose policies that influence both who gets elected in the future, and the policies future governments will implement.

These strategic policy manipulation effects have traditionally been studied by supposing that different parties have common beliefs, but heterogeneous objectives (e.g. Persson & Svensson, 1989). Yet heterogeneous beliefs also give rise to strategic incentives for policy manipulation. Millner et al. (2014) demonstrate that when parties have good faith

[10] Voters in general elections can of course also abstain, however this effect is unlikely to be relevant in this case, as voters rationally assign very low probability to the chance of being pivotal in large elections.

disagreements about the consequences of 'long-run' policies, incumbents have an incentive to 'over-experiment', i.e. do more than they would like to reduce uncertainty about policy consequences in the future. The intuition behind this is simple – policy experimentation reveals common information, which brings opposing parties' beliefs closer together. Incumbents prefer to face opponents more like themselves in future political contests, as this reduces the time-inconsistency problem. They thus have an incentive to use current policy choices to reduce the disagreements between parties – hence, they over experiment. As an example of the application of this mechanism, consider the case of 'fracking', which provides short-run economic benefits, but uncertain long-run environmental costs. These arise due to groundwater contamination from the chemicals used in the fracking process. These costs depend on the chemical mix in the fracturing fluid and the geology of the site, and are difficult to predict *ex ante*. The only sure way to resolve uncertainty about costs is to observe them *ex post*. The mechanism predicts that if parties disagree on the likely magnitude of these costs, even well intentioned incumbents will have an incentive to regulate fracking less stringently than they would like. This reveals information about costs, and thus allows incumbents to avoid future political contests with opponents whose beliefs are very different to their own.[11]

Persuasion: Experts and Lobbies

Where do policy makers get their information from? Expert communities such as the National Academy of Sciences or the Intergovernmental Panel on Climate Change provide the scientific background to policy debates, but politicians are also strongly influenced by lobby groups. Unfortunately, the boundaries between 'experts' and 'lobbies' can be blurred. Some politicians may view prominent scientific groups as a 'lobby', and scientists hired by organized commercial interests as 'experts' (Oreskes & Conway, 2012).

[11] See also Majumdar & Mukand (2004); Strulovici (2010); Callander & Hummel (2014) for further studies of the effect of political competition on policy experimentation.

The difficulty for the politician is that she knows that everyone wants something from her. Given this, how can she believe that the information being fed to her is not distorted to serve the provider's interests? A large literature in economics addresses precisely this kind of strategic information transmission problem. Crawford & Sobel (1982) introduced the classic model of 'cheap talk', in which a more informed sender costlessly transmits a signal to a less informed receiver, who then takes an action that affects both parties' (non-identical) payoffs. Despite the fact that the receiver knows that the sender aims to manipulate her actions, information can still be revealed in equilibrium. Precisely how much information is revealed depends on the alignment between the sender and receiver's objectives – the more closely aligned they are, the more information is revealed. This classic result suggests that we need not be wholly pessimistic about the possibility of information transmission between strategic parties with different objectives, provided they are not *too* different. More encouragingly, Krishna & Morgan (2001) show that when the decision maker can sequentially consult multiple informed experts with opposing objectives she may be able to extract all their information. Battaglini (2002) obtains a similar full information revelation result when policies are multi-dimensional.[12]

This set of results assumes that experts have genuine information that the planner would actually find useful. Unfortunately, some people may have more mercenary motives – they may be 'experts for hire', who adapt their policy message to the interests of their employer. Alternatively, they may have fringe views based on dubious science, but which policy makers are unable to distinguish from scientifically sound opinions. Shapiro (2014) examines these effects in a model in which competing special interests seek to influence opinion through the media. Special interests can create the illusion of scientific disagreement where none exists by hiring contrarian 'experts', and their incentive to do so is greater when the scientific consensus is strong, and the economic stakes are high. This can mean that the public and policy makers will remain uninformed, despite growing

[12] Kamenica & Gentzkow (2011) study a related problem in which a sender commits to communicate any information she may discover to a Bayesian receiver, but is free to design the information discovery process to her advantage. They show that even though the receiver knows exactly how the discovery process has been manipulated, he can often be persuaded to take actions that benefit the sender.

scientific agreement about a policy issue. Empirical evidence suggests this has occurred in the case of climate change. Shapiro shows that people who consume more news are *not* more likely to believe that there is 'solid evidence that the earth is getting warmer', but *are* substantially more likely to be informed about other matters of current affairs. This suggests that special interests have successfully planted doubt in the public's minds, where little exists in the scientific community. These effects are stronger in countries and states where journalists believe that 'objectivity' means 'expressing fairly the position of each side in a political dispute', regardless of the veracity of different viewpoints.

Conclusions

The legal scholar Cass Sunstein has observed that 'The government currently allocates its limited resources poorly, and it does so partly because it is responsive to ordinary judgments about the magnitude of risks.' (Sunstein, 2000). There are two components to this claim: first, that the public's beliefs about risks are likely to be inaccurate, and second that these inaccuracies filter through the political system, and affect government decision-making. While both these components may seem uncontroversial, neither of them is self-evident. Perhaps social interactions can ameliorate individual biases, and perhaps political institutions can aggregate opposing viewpoints, resulting in policy choices that reflect a balanced consensus?

Our survey of the literature suggests that behavioral biases, social interactions, and the influence of the media are indeed likely to lead both individuals and groups to misestimate environmental risks. In addition, while democratic institutions can provide some checks on the influence of biased beliefs, they can also induce their own informational distortions into the policy process. While biases in risk perception and informational distortions to the policy process are issues that are relevant to many policy issues, they are especially important for global environmental problems. We argued that these problems have a peculiar set of characteristics that make them unlikely to be accurately assessed by non-

specialists, including policy-makers themselves.

While we have sketched several mechanisms that may distort the informational inputs to environmental policy-making, many open questions remain. What determines whether we are likely to under- or overreact to a given environmental threat? Are some governance systems more likely to adopt policies informed by the best available scientific information than others? Which behavioral biases are the most important determinants of misperception of environmental problems? How important are belief distortions as an explanation of sub-optimal regulation, relative to more familiar explanatory factors such as international free riding problems, and domestic special interest politics?

Finally, while we have argued that understanding the factors that shape beliefs is a central task of the positive theory of environmental regulation, we are ultimately interested in what can be done to guard against the influence of flawed 'ordinary judgments', and willful misinformation. Ensuring that policy-makers and the public have access to a basic scientific education, while a necessary step for a more measured response to risks, is unlikely to be sufficient. Kahan et al. (2012) suggest that a high level of numeracy is no guarantee that people's assessments of environmental risks will be closer to the scientific consensus.

A more satisfactory answer is likely to require reforms in the way that the media and government engage with scientific information. The journalistic norm of equal treatment of opposing viewpoints has done considerable damage to the public's understanding of complex issues such as climate change. Fair reporting does not mean equal column inches to every viewpoint, but rather a careful assessment of the merits of different arguments. It is unclear however how this norm can be changed, except by journalists themselves. It is also notable that while central banks have apolitical influence over monetary policy, and social security programs provide a means of overcoming savers' self-control problems, no comparably powerful institutions or regulations exist to ensure that environmental policies are

informed by the best available scientific knowledge, and that behavioral biases do not overly influence policy choices.[13] It remains to be seen whether institutions such as the National Academy of Sciences and the Royal Society can play a more formal role in distilling scientific consensus, and providing the informational basis for environmental policy.

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[13] While Executive Order 12866 requires US government agencies to assess the costs and benefits of regulation, there is at best mixed evidence that these assessments result in efficient policy choices (Anthoff & Hahn, 2010). Behavioral and political factors are strong determinants of whether regulations are implemented (e.g. Viscusi & Hamilton, 1999).

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