Political Cleavages and Changing Exposure to Global Warming

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Abstract

Why do some countries, cities, firms, and individuals curtail greenhouse gas emissions that cause climate change but not others? Prevailing explanations focused on collective action and distributive politics assume all actors face negative costs from global warming; yet this is at odds with research that finds considerable heterogeneity in climate change's economic effects. We amend the standard distributive theory with a richer set of preferences derived from a dynamic economic assessment model of global warming. We provide evidence that as actors update their beliefs about the effects of climate change, countries and cities are more likely to mitigate emissions if they face net damages but not if they experience potential net gains. This suggests that the physical damage of global warming, not incumbent interest groups nor free riding, will increasingly dominate decisions to abate carbon pollution.

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1 Introduction

Why do some countries, cities, firms, and individuals act to reduce greenhouse gas (GHG) emissions but not others? Given the scientific consensus that global warming requires urgent and deep cuts to carbon pollution, coupled with the profound integration of fossil fuels into the global economy, climate policy is an issue of intense political contestation. All actors have a stake, either through the physical damage from climate change or the costs of adjusting to regulations.

Prominent theories of collective action (Barrett 2003; Keohane and Victor 2016; Nordhaus 2015; Ostrom 1990; Stern 2007; Victor 2011) and distributive politics (Aklin and Urpelainen 2018; Aklin and Mildenberger 2020; Breetz, Mildenberger, and Stokes 2018; Colgan, Green, and Hale 2021; Cory, Lerner, and Osgood 2021; Meckling 2011; Mildenberger 2020) assume that universal damages exist; that is, all are hurt by global warming, although some more so than others. For collective action, this permits the characterization of carbon abatement as a public good, since all actors value its provision. For distributive politics, the universal damage assumption is necessary to make sense of why actors not invested in fossil fuels or green energy might support climate policy. However, this premise is at odds with emerging stream of research that finds considerable variation in global warming's economic damages (Diffenbaugh and Burke 2019; Kotz et al. 2021; Moore and Diaz 2015; Piontek et al. 2021). Strikingly, there are sharp geographic differences in climate change's effects, with the potential for long-run benefits in higher latitude regions with colder baseline temperatures currently (Callahan and Mankin 2021; Cruz and Rossi-Hansberg 2021; Burke, Hsiang, and Miguel 2015; Burke, Davis, and Diffenbaugh 2018; Desmet et al. 2021; Hsiang et al. 2017; Krusell and Smith 2020; Nordhaus 2006; Rode et al. 2021). While the worldwide aggregate losses are negative and from a normative perspective warrant a strong governmental response, theory must be guided by the world as it is rather than what social scientists hope it to be.

We amend the standard distributive politics theory to account for the full range of global warming's potential damages and benefits. Incorporating the possibility of localized benefits from climate change generates new theoretical insights. In particular, we predict that as information about climate change's effects diffuses, a new political cleavage is emerging between actors in the Global North that face possible net benefits and those in the South that face potential net damages.[1] One potential equilibrium is a *climate war*, where actors cannot agree on the ideal temperature of the Earth, and the North continues to pollute unabated while the South curtails its emissions. The other equilibrium is a *climate bargain*, where actors experiencing potential losses compensate the potential winners in exchange for their abatement of carbon pollution. While perhaps politically unthinkable now, this pattern of compensation may become realistic as climate damages intensify.

We evaluate the extent to which climate cleavages have formed along the lines we theorize by examining the actions countries and cities have taken to curtail emissions. While states are the conventional unit of analysis in international relations, we also examine cities because they are playing an increasingly consequential role in the fight against global warming. We derive actor preferences over temperature from Cruz and Rossi-Hansberg's (2021), henceforth CR, dynamic economic assessment model. This spatially disaggregated model of the world economy quantifies the long-run effects of higher temperatures on productivity and living amenities at a rich level of geographic detail. Productivity refers to the efficiency of economic activity, and amenities are features that make a place desirable to reside, such as health, education, and governance. The model assumes the most pessimistic warming scenario identified by the Intergovernmental Panel on Climate Change (IPCC) and notwithstanding finds potential for net gains from higher temperatures. Then we leverage satellite data on heat anomalies to measure growing awareness of climate change. The results show that as countries and cities experience more extreme temperatures, only actors facing potential damages respond by mitigating emissions. To validate this particular information updating

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[1] Our designation of North and South is on the basis of climate damages. This categorizes China as a member of the North according to one damage metric, whereas India and parts of Southern Europe are in the South.

mechanism, we investigate cross-national patterns of climate attitudes, finding that popular concern about climate change increases in areas set to experience potential damages, all else equal.

To explore the standard distributive politics model, we control for the strength of polluting interests. We find that except for some edge cases, such as petro-states, the physical damage of climate change consistently explains actors' climate mitigation behavior. As a direct test of the collective action problem's free riding hypothesis, we employ a spatial model of interdependence and reciprocity, and discover that free riding is decreasing over time as countries update their beliefs about climate change's effects.

These findings have stark implications for climate politics. In particular, the results predict the opposite pattern of bargaining between countries than standard academic and journalistic accounts typically assume. Rather than rich countries cajoling poorer nations into reducing emissions, the tables will increasingly turn as climate change accelerates. Developing countries in the Global South may find themselves persuading, and potentially coercing, actors in the North into curbing their pollution. This has ethical implications, as many argue that rich nations with a legacy of emissions have an obligation to compensate developing countries as they adapt to climate change; yet the relative resilience of economies in the North to climatic damages may block political support for an equitable settlement.

2 Why Have Actors Failed to Mitigate Emissions?

Existing explanations for (in)action on climate change fall into two camps: collective action and distributive politics. Both theories rely on the universal damage assumption that all actors incur costs from climate change. However, this runs counter to an emerging stream of research that finds substantial heterogeneity in global warming's consequences for fundamental amenities and productivities (Cruz and Rossi-Hansberg 2021), gross domestic product (Burke, Hsiang, and Miguel 2015; Burke, Davis, and Diffenbaugh 2018; Callahan and Mankin 2021; Desmet et al. 2021; Kotz et al. 2021; Nordhaus 2006), total factor productivity growth and capital depreciation (Moore and Diaz 2015), agriculture (Conte et al. 2021; Mendelsohn, Nordhaus, and Shaw 1994), manufacturing (Desmet and Rossi-Hansberg 2015), energy consumption (Rode et al. 2021), crime, coastal storms, labor (Hsiang et al. 2017), and human mortality (Carleton et al. 2020). Disparate economic damages and benefits obtain even when accounting for increases in the variability of temperature (Callahan and Mankin 2021). While disagreement persists about the precise magnitude of the economic effects, there exists consensus that in both the short- and long-run, higher latitude regions will be better off in terms of metrics such as GDP, even if all experience net losses. The remainder of this section explicates how prevailing theories rely on this assumption and the analytical consequences.

First, collective action theory views the climate as a global public good and incentives to free ride on the emissions abatement of others as the defining strategic problem (Barrett 2003; Keohane and Victor 2016, 2011; Nordhaus 2015; Ostrom 1990; Stavins 2011; Sandler 2004; Stern 2007; Victor 2011). Reducing climate change requires costly actions from all states, while the benefits from this are captured by everyone regardless of whether they helped. Because the cost-benefit calculations of national policymakers, firms, and individuals fail to completely capture the beneficial effects of their actions on global welfare, the aggregation of individual actions to mitigate climate change will be less than the ideal from a global viewpoint.

However, the characterization of the climate as a global public good assumes that all actors benefit from its provision. This is implied by the universal damage assumption; since all actors are harmed by climate change, then all must benefit from emissions reductions. This is crucial to interpret the failure of countries to reduce emissions as free riding. However, if actors enjoy potential net benefits from higher temperatures, this lends a new interpretation to inaction. Countries defect from providing the public good, not out of free riding calculations, but because they have higher temperature ideal points.

Few studies of politics have united collective action dynamics with explicit models of climate change's economic effects, which is necessary to defend the universal damage assumption and evaluate its empirical implications. While research in economics leverages integrated assessment models of global warming to find efficient policies that ameliorate free riding (e.g. Nordhaus 2015), the models remain at a coarse resolution that cannot capture differences in temperature damages and benefits within and between countries (Cruz and Rossi-Hansberg 2021).

Yet understanding this spatial heterogeneity in global warming's distributional effects is necessary to construct sound theories of climate politics. For example, a vibrant stream of scholarship takes incentives to free ride as the starting point, then explores how leadership (Busby and Urpelainen 2020; Hale 2020), institutions (Barrett 2003; Heitzig, Lessmann, and Zou 2011; Keohane 1984; Nordhaus 2015; Schmidt and Ockenfels 2021; Victor 2011) or reciprocity might alter payoffs (Keohane and Victor 2016; Ostrom 2009). These solutions to free riding presume actors have the first-order preferences to implement them. However, whether a country is willing to act as a first mover, establish optimal institutions, or pursue a strategy of reciprocity depends on whether it is in an actor's interest to provide the public good. Some countries may be less motivated than others if they are shielded from the physical consequences of global warming and face plausible net benefits. Though there is excellent survey research linking public attitudes on climate cooperation with solutions to free riding, such as agreement design (Bechtel and Scheve 2013; Bechtel, Scheve, and van Lieshout 2021), reciprocity (Tingley and Tomz 2014; Beiser-McGrath et al. 2021), and shaming (Tingley and Tomz 2021), scholars have so far reached conflicting findings and it is unclear whether the survey results scale up to explain cross-national variation in climate policy outcomes (e.g. Aklin and Mildenberger 2020; Beiser-McGrath and Bernauer 2019).

The "meta-theoretical alternative" to the collective action problem is distributive politics (Aklin and Mildenberger 2020, 10). This framework views climate politics as a conflict between politicians, voters, and interest groups. Bold action to reduce GHG emissions creates economic winners and losers, and the strength of pro- and anti-climate coalitions determines whether national governments adopt climate policy (Colgan, Green, and Hale 2021; Meckling 2011; Mildenberger 2020; Stokes 2020).

While the distributive politics literature has a clear explanation for why actors oppose climate policy – the cost borne by polluting sectors (Aklin and Urpelainen 2018; Bechtel, Genovese, and Scheve 2019; Breetz, Mildenberger, and Stokes 2018; Cory, Lerner, and Osgood 2021; Genovese 2019) or the expense incurred by consumers of clean energy (Ansolabehere and Konisky 2014) – it lacks a cohesive model of why actors support carbon abatement. Instead there are a smattering of explanations: green energy interest groups may lobby for climate policy out of economic self-interest (Aklin and Urpelainen 2013; Meckling et al. 2015; Meckling, Sterner, and Wagner 2017; Stokes 2020); governments may support green industrial policy to bolster competitiveness (Hughes and Meckling 2018); heterogeneous regulatory costs may turn emissions restrictions into a tool to undermine a firm's competitors (Kennard 2020); state and environmental groups, compelled by normative concerns, may act as a countervailing force on businesses (Meckling 2011); and physical vulnerability to climate change combined with fossil fuel investments create cross-cutting preferences (Colgan, Green, and Hale 2021; Gaikwad, Genovese, and Tingley 2021; Sprinz and Vaahtoranta 1994).

All else equal, these studies explain disparate pieces of the climate puzzle. The closest to a unifying model of climate preferences is Colgan, Green, and Hale (2021), whose insightful article conceptualizes actors' preferences as a function of their ratio of climate-vulnerable to climate-forcing assets, and the ease with which they can exit or transform their holdings. Pure climate-vulnerable asset holders should support emissions restrictions, whereas no-exit carbon-forcing asset holders should defend the status quo. While this theory is brilliant in its parsimony, it does not provide a practical guide to generate predictions as to which assets and locations are vulnerable, a necessary step for empirical validation. Though certain answers are intuitive, like coastal regions, absent a model of the climate, these assumptions cannot be taken as a given. Sea level rise, for instance, occurs unevenly, and is even forecasted to *retreat* in places such as Juneau, Alaska (Desmet et al. 2021).

Further, like collective action theory, the standard distributive politics model only considers the potential damages of climate change. The magnitude of climate damages implied would make it especially puzzling why governments, even myopic ones captured by fossil fuel interests, have not not implemented aggressive measures to constrain emissions. However, this inaction becomes more understandable if citizens, firms, and interest groups face differential climate damages. Actors less exposed to the physical effects of global warming, especially those experiencing net benefits, would have little incentive to curb emissions.

3 Modeling Climate Change's Distributive Effects

This section introduces a model of global warming's economic effects, which provides the foundation to derive actors' preferences over temperature from climate change's distributive consequences. We employ an Integrated Assessment Model (IAM), the prevailing technique for quantifying global warming damages (Auffhammer 2018). For background, IAMs consist of three components: (i) a model of the socioeconomic scenarios that produce GHGs; (ii) a mapping between emissions concentrations and future climate outcomes; and (iii) a damage function that connects climatic changes with economic metrics of interest.

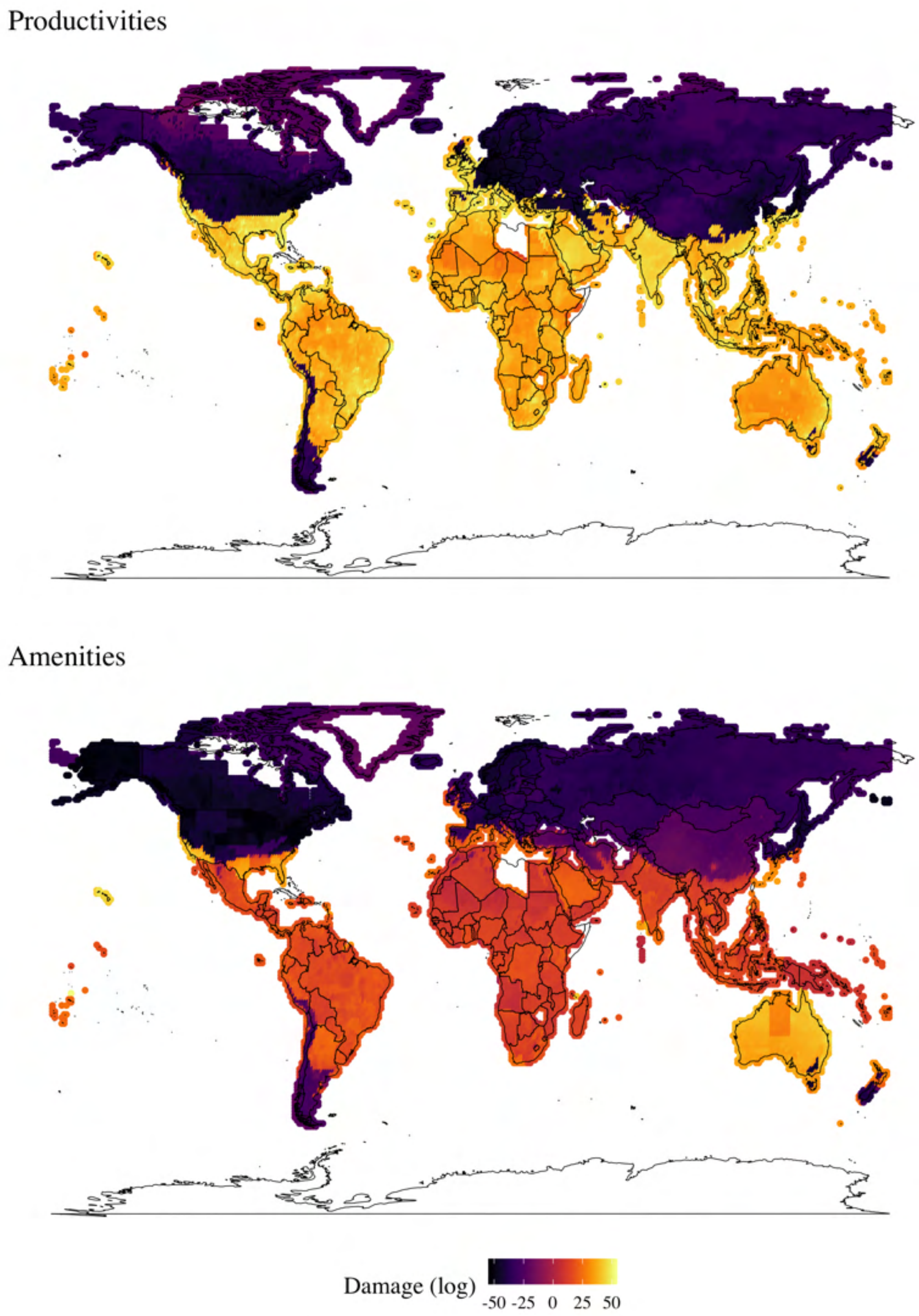
We leverage CR's dynamic economic assessment model for three reasons. First, it measures spatial heterogeneity at a high resolution, which allows us to map the results onto political units across levels of analysis. Second, unlike previous models, CR endogenize adaptation into the damage function through migration, trade, and innovation, which provides a microfounded and realistic depiction of global warming's economic effects. Third, the model accounts for interdependence of locations through trade. This is relevant in a globalized world where actors may still care about climate change outside of their region if it affects trading partners.

Online Appendix A provides an informal description of the model's set up. Most relevant is how CR assess the economic effects of temperature changes. This occurs through three channels: amenities, productivities, and natality rates. Recall that amenities refer to utility an individual receives from the place they live, and productivity refers to the effectiveness of economic activity in a location. Amenities are important because they capture quality of life and incentives to migrate. Likewise, productivity matters because it determines an area's ability to grow and increase its standard of living. We prefer these disaggregated fundamentals because they capture underlying dimensions of individual and firm incentives. To estimate the damage functions, CR invert the model using bidecadal data from 1990 to 2005 on wages, population, land, and energy prices.

After quantifying the model at the $1^\circ \times 1^\circ$ spatial resolution, CR simulate the economy from 2001 through 2400. The simulation compares a world where temperature does not affect economic fundamentals to a baseline scenario where temperature influences amenities, productivities, and natality rates. Both counterfactuals assume a worst-case "business as usual" scenario with no binding global climate policy, specifically the IPCC's Representative Concentration Pathway (RCP) 8.5.

This exercise reveals that latitude, elevation, and coastline – exogenous geographic features – determine whether a location experiences potential damages or benefits to amenities and productivities. Unlike collective action theory and the standard distributive politics model, CR show the potential for gains from global warming, in addition to higher than expected spatial heterogeneity in damages. Figure 1 illustrates how global warming's economic effects split horizontally across the Earth. The Global North experiences gains in amenities and productivities relative to a world without warming due to its lower baseline temperatures and redistribution of economic activity through migration and agglomeration. In continental terms, this area spans North America and Eurasia. A wide southern band suffers severe damages. In particular, South America, Africa, South Asia, and Oceania experience declines in amenities, productivities, and population density.

At the country level, nations can be grouped into those experiencing potential net dam-


Productivities

Amenities

Figure 1: Effect of global warming on productivities and amenities in 2100. The Global North and South experience disparate outcomes, denoted by the potential damages in orange and potential gains in purple. Dynamic economic assessment model from Cruz and Rossi-Hansberg (2021). Damage adjusted for interpretation by taking the log of the absolute value, then multiplying by -1 if the location experiences potential benefits.

ages and benefits (Online Appendix B provides a list). A non-exhaustive collection of countries facing potential damages includes Brazil, Nigeria, India, Spain, and Papua New Guinea. In contrast, Canada, Russia, Mongolia, the United States, Norway, and Czechoslovakia may experience potential net gains in amenities and productivities. While in aggregate, the global economy incurs substantial losses, this statistic masks substantial heterogeneity between and within countries.

At the subnational level, global warming will also have differential effects. Take the United States, where the southern most states face substantial damages, while potential benefits increase moving northwards along the eastern seaboard and in the upper Midwest. Hsiang et al. (2017) find a similar pattern at the county level, providing external validation of CR's model. China also confronts significant sub-national heterogeneity in climate impacts. Much of southeast China will face lower amenities and productivities as local temperatures rise. However, potential damages decline moving northward towards the capital Beijing, and the northwest will see potential gains.

For nations facing heterogeneity, it makes sense to speak of *net* gains and losses. However, while there is some subnational heterogeneity, many countries due to their size or geography face little internal variation in damages or benefits. The model shows that Canada and Russia experience fairly uniform potential benefits. In contrast, places like Brazil, Mali, and Indonesia confront uniform damages. For these actors, the damages and benefits in terms of direct temperature effects may be *absolute*.

For a reader unfamiliar with the climate econometrics literature, the notion of potential benefits from climate change may be surprising. This reaction is in part due to the tendency to describe global warming in aggregate terms. Previous research has proceeded at a coarse regional resolution, save for the occasional country-specific study. Yet even these coarser studies find heterogeneous, though not always positive effects on economic growth (e.g. Burke, Hsiang, and Miguel 2015; Burke, Davis, and Diffenbaugh 2018; Kotz et al. 2021; Moore and Diaz 2015; Nordhaus 2006). Moreover, these older models do not account for adaptation, which is essential to accurately quantify climate damages. Agents are not passive in the face of higher temperatures, but will migrate, trade, and innovate to minimize potential harm. One such example of adaptation is the deployment of air conditioning, which reduced mortality from extreme heat in the United States by 75 percent (Barreca et al. 2016). By endogenizing adaptation into their damage functions, CR provide a more credible model of climate change's consequences. Of course, not all countries can afford to adapt, which will only deepen inequality between richer, cooler places and poorer, warmer areas. In a related context, Carleton et al. (2020) incorporate adaptation into their analysis of temperature's effect on mortality and find that today's cold locations benefit while poor, hot areas incur damages. Lastly, we emphasize that this spatial distribution of damages and benefits is not unique to CR. Studies using diverse techniques and modeling assumptions find similar disparate patterns of losses and gains from higher temperatures (Burke, Hsiang, and Miguel 2015; Burke, Davis, and Diffenbaugh 2018; Callahan and Mankin 2021; Diffenbaugh and Burke 2019; Hsiang et al. 2017; Krusell and Smith 2020; Nordhaus 2006).

Nonetheless, there are relevant scope conditions in applying CR's model. First, while the failure to account for adaptation may bias previous models in favor of higher damage estimates, the exclusive focus on temperature by CR may introduce countervailing bias due to climate hazards unrelated to temperature such as sea level rise (SLR) and tropical cyclones. There is no comprehensive study that evaluates all dimensions of climate damages on a global scale, so it would be speculative to conclude whether the sources of bias cancel out. However, there are good reasons to expect that non-temperature climate hazards also have heterogeneous consequences. Desmet et al. (2021) find that SLR creates winners and losers as economic activity redistributes inland. By the same logic, it is likely that migration in response to tropical cyclones will benefit unexposed interior regions. In our subsequent empirical tests, we account for damage from SLR and the results remain unchanged (Online Appendix L). Second, any estimate of climate change's economic effects is inherently uncertain given the time span of the forecast. However, while uncertainty exists about the precise magnitude of damages and benefits, CR's model yields precise predictions about the spatial distribution of global warming's effects, which allows us to derive stable preferences that account for the full range of temperature's economic consequences unlike the collective action theory and standard distributive politics model.

4 Theory of Climate Cleavages

This section uses the distributional consequences of global warming implied by CR's model to derive actors' climate preferences. These are preferences not over particular policy instruments, but over the ideal temperature of the Earth. We orient our approach around preferences because they are the heartbeat of politics. To know who gets what, when, and how, requires a theory of who *wants* what, when, and how. That is, scholars must theorize the underlying interests of actors. Even theories that do not delineate preferences rely on implicit conjectures about the goals of actors. Employing an explicit model of preferences adds needed analytical clarity, and has served as a generative basis for research in many paradigms, such as Open Economy Politics (e.g. Lake 2009).

Our central theoretical argument is that as actors update their beliefs about the severity of global warming in response to observed climate change, they will respond according to whether they face potential net damages or benefits from higher temperatures. Actors that prefer lower temperatures are more likely to curtail their emissions, whereas actors that prefer higher temperatures are more likely to continue polluting. This theory is general, applying across countries, cities, firms, and individuals. Each occupies a particular location that, depending on exogenous geographic attributes, may lose or gain from climate change. The effects may be largest for actors like countries and cities that cannot relocate. Firms and individuals, in contrast, have greater capacity to adapt through migration, although they incur a cost for doing so.

Information serves as the underlying mechanism that motivates actors to respond to climate change, conditional on whether they anticipate net economic damages. While a location's vulnerability to global warming is objective, people may lack awareness of the pace at which climate change is accelerating and how it might impact them. However, as individuals experience more heat waves, droughts, wildfires, floods, and hurricanes, all intensified by global warming, they will update their beliefs about the likelihood of being impacted. The effects of temperature fluctuations are extensive and will arise in unexpected ways (Choi, Poertner, and Sambanis 2021). There is evidence that, independent of partisan affiliation and socio-demographic factors, experiencing hot temperature fluctuations increases belief in global warming (Bohr 2017; Howe et al. 2013; Deryugina 2013; Marlon et al. 2021), in addition to climate concern (Bergquist and Warshaw 2019). These attitudinal responses have consequential behavioral implications. Concern about climate changes leads individuals to search for information about global warming online (Kennard 2021), and heat anomalies increase vote share for Green parties (Hoffmann et al. 2021). A similar relationship also appears among elites, with bureaucrats working in climate vulnerable areas being socialized into viewing global warming as a more urgent problem (Clark and Zucker 2021). Firms also exhibit updating behavior in response to temperature fluctuations (Kelly, Kolstad, and Mitchell 2005). Although there are sometimes mixed findings due to differences in research design (Howe et al. 2019), the effect of temperature should only grow in magnitude as climate change accelerates.

This updating mechanism implies that people should care most about easily observed damages. Earlier we disaggregated the economic effects of climate change into local amenities and productivities. In terms of these fundamentals, amenities should be more salient to individuals as they are easier to identify through lived experience. Thus, we should see stronger updating patterns among actors facing potential amenities damage. Productivities also matter, but it may be harder to cognitively connect short-run fluctuations in weather to changes in the efficiency of economic activity in a location.

These are not purely theoretical claims. Countries are paying attention to the potential damages of global warming. Colombia, for example, has pledged an especially ambitious Nationally Determined Commitment (NDC) under the Paris Agreement. Colombia's pledge acknowledges that its emissions are unlikely to be pivotal, but that "[n]otwithstanding... Colombia is highly exposed and sensitive to the impacts of climate change, given its diverse geography and economy, which is highly dependent on the climatic conditions and the use of natural resources."[2] Nations are also likely to become more aware of potential climate benefits. For example, the global accounting firm Deloitte released a report that showed climate change would increase Czechoslovakia's GDP. Though the report was ultimately withdrawn due to public pressure, it illustrates a potential mechanism by which actors will learn about global warming's differential effects.[3] Knowledge of climate change's potential benefits may also transmit to the public through the media. In Canada, one of the leading news outlets reported on scientific studies that showed local agricultural benefits from higher temperatures.[4]

In response to increasing awareness of climate change, actors have two classes of actions they can take to manipulate global temperatures: add and remove GHG emissions. Countries, cities, firms, and individuals can add emissions by continuing along a business as usual path with no restrictions on fossil fuels consumption and extraction. Though inaction may appear passive, it is a tacit decision to pollute. In contrast, countries and cities can remove emissions by placing restrictions on fossil fuels, creating incentives for clean energy alternatives, or pursuing geoengineering technologies that remove carbon from the atmosphere. Firms could invest in carbon-neutral production processes and electrify their operations. Individuals might adopt behavioral changes to reduce their carbon footprint or vote for pro-climate leaders. These actions are not exhaustive, but provide an overview of available

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[2] UNFCC registry, "Colombia First NDC (Archived)," https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Colombia%20First/Colombia%20iNDC%20Unofficial%20translation%20Eng.pdf.

[3] France 24, "Big Four accounting firm sees upside to climate change," September 26, 2020, https://www.france24.com/en/20200925-big-four-accounting-firm-sees-upside-to-climate-change (Accessed September 29, 2021).

[4] "Canada could be a huge climate change winner when it comes to farmland," CBC, February 12, 2020, https://www.cbc.ca/news/science/climate-change-farming-1.5461275 (Accessed October 5, 2021).

options.

Given the sharp bimodal distribution of potential damages and benefits, we predict that the Global North and South will have diametrically opposed climate preferences, all else equal. Actors in northern latitudes face potential net gains from a warmer world, and should be more likely to pollute unabated, whereas actors in southern latitudes suffer intense net damages, and should be more likely to curtail their emissions. Since the emissions by the Global North cause direct economic harm to the Global South, a new political cleavage may form between the hemispheres. Just as divisions between urban and rural or rich and poor are thought to structure other dimensions of politics (e.g. Lipset 1959), whether an actor faces potential climate damages or benefits may act as a new axis of political conflict. The reason climate change is serious enough to transcend other cleavages is its immense scope. CR's model shows that actors in the Global South face welfare losses as large as 19 percent, whereas the North may experience welfare gains as large as 14 percent in terms of present discounted utility. These effects are already occurring; Diffenbaugh and Burke (2019) estimate that global warming has increased between-country inequality by 25 percent, with poorer, hotter countries experiencing declines in economic output, while cooler, wealthier countries have gained. This emerging climate cleavage, the result of geography, may define bargaining between actors in the centuries to come.

> *Hypothesis:* As actors update their beliefs about the severity of global warming, actors set to experience potential net damages should be more likely to take actions that curtail GHG emissions than those experiencing potential net gains.

Two potential equilibria may result from this cleavage: climate war and climate bargain. First, in the *climate war* equilibrium, actors in the Global North and South fail to reach a settlement over the ideal temperature of the Earth. Just as Grossman and Helpman (1995) show how trade wars can result from governments behaving unilaterally and ignoring the impacts of their actions on agents in other countries, the unabated pollution by the North could lead the South to pursue countervailing strategies to neutralize the North's pollution.

Geoengineering to alter the global climate is likely to be tried because these technologies are cheap, can be unilaterally deployed, and even if expensive, could be sponsored by a coalition of countries (Schelling 1996; Victor et al. 2009). However, technological fixes may only reduce carbon levels, which enables the Global North to pollute further. Plus, the North may prefer higher temperatures and have an incentive to pollute or halt actors in the South from deploying geoengineering techno-fixes. Usually carbon is thought of as a negative externality, but if areas of the globe benefit from warmer temperatures, removing carbon could also impose non-internalized costs on higher latitude actors.

In addition to countervailing strategies, actors in the South may also leverage direct and indirect tools of coercion to compel the North to reduce its emissions. For example, countries may impose negative incentives in the form of carbon tariffs; they may press their people to migrate north; or they may hold up cooperation on important issues to polluting countries. While climate clubs that sanction non-members with carbon tariffs are often proposed as a solution to the free riding problem (e.g. Nordhaus 2015; Victor 2011), scholars typically assume the inaugural members are wealthy nations in the North. Our theory suggests that as climate change accelerates, countries in the South are the most likely candidates to establish such institutions.[5]

Juxtaposed to the climate war outcome is the *climate bargain* equilibrium. Here, actors in the North and South strike a settlement on the ideal temperature of the Earth. Actors facing losses in a world with climate change compensate those that benefit for forgoing their potential net gains. This would amount to transfers, direct and indirect, from the South to the North in exchange for curtailing emissions, which may be necessary for an efficient global carbon pricing regime (Kotlikoff et al. 2021). This has troubling normative implications, since actors in the North contributed the most to emissions that cause climate change. There is initial evidence that resilient agents do not take advantage of the vulnerable

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[5] While actors, such as the European Union, are moving towards carbon border adjustments, the stringency of these measures is questionable. More importantly, many actors in Southern Europe face potential damages, so this behavior accords with our theory.

(Mahajan, Kline, and Tingley 2021), but it is unclear whether this will continue as the effects of climate change increase.

Who sets the terms of the bargain will stem from who has power, which in this context is a function of an actor's level of emissions and costs of abatement. China, India, and the United States, for instance, account for roughly half of global CO_2 emissions, and thus have disproportionate influence on the global temperature (Victor 2011). It is not just present emissions that matter, but also the future ability to influence GHG concentrations. Certain actors have natural endowments, such as forests that sequester carbon dioxide, which can be leveraged strategically to obtain concessions from actors that prefer lower temperatures. Actors that face potential gains could threaten to ramp up emissions in order to extract concessions from the South. Although this is risky because actors must believe they can achieve their temperature ideal points without overshooting. Since CO_2 is a stock pollutant, emissions are difficult to roll back absent negative emissions technologies. So the decision to add emissions is potentially costly if countries miscalculate.

While domestic and international institutions play a meaningful role in aggregating the preferences of actors as they bargain over emissions abatement, we bracket them for parsimony. Our theory is a first order concern since without an underlying model of preferences, institutional approaches lack strong explanatory power. It does not automatically follow, for instance, that democracies will institute pro-climate polices if citizens of the nation are unexposed to the negative effects of climate change. The mis-specification of preferences, or failure to specify them altogether, may explain the conflicting findings in the environmental politics literature. Some claim electoral accountability leads democracies to supply public goods, and a free press provides information about environmental problems that the public acts upon (c.f. von Stein 2020). Yet, the evidence for positive outcomes is inconclusive, which Bättig and Bernauer (2009) attribute to international free riding. Others argue that democracy may be counterproductive because political constraints undermine the government's ability to act swiftly on environmental issues (Gilley 2012). Our theory suggests that these studies may be confounded by the underspecified dimensions of actor preferences.

In the context of international politics, our theory predicts the opposite pattern of bargaining than is currently assumed. The conventional account is that the North is struggling to cajole developing countries in the South to curb their emissions. In contrast, our theory forecasts that this pattern of bargaining will reverse as the damage of global warming accelerates and publics become more aware of climate change's effects. While it may appear that developing countries are resisting carbon abatement, our theory shows that this is a strategic choice to obtain greater concessions, which underscores one problem in deriving preferences from observed outcomes.

Our theory contradicts a central premise of collective action, that supplying the good provides actors a common benefit. This casts the decision to pollute in a new light. Rather than free riding due to the failure of private costs and benefits to reflect the externalities on other actors, reducing emissions might be a public *bad* for the North which experiences potential net benefits from higher temperatures. For actors in the South facing intense damages, their incentives to free ride also depart from the standard model of collective action. Increasing knowledge that the North will not abate pollution, plus recognition of the common cost the South will incur, reduces the probability that the public good will be provided absent contributions from agents in the South. Further, while at first glance the benefit of pro-climate action may appear minimal, the effects of even small emissions reductions now compound over time, producing an appreciable effect. This is especially true for developing countries whose energy consumption is forecast to grow substantially.

These twin dynamics suggest that the appearance of free riding may be a historical artifact from a period where climate change was of lower salience, but holds less and less as actors increasingly understand how climate change will affect them. This may be a more pessimistic conclusion than collective action theory implies, because it suggests larger transfers are needed to compel countries in the North to act.

With respect to distributive politics, incorporating potential benefits from global warming yields new predictions. For example, low-carbon workers in regions with higher temperature ideal points might oppose climate policy, adding a novel dimension to Mildenberger's (2020) theory. Likewise, climate-exposed sectors such as agriculture may experience damages in areas near the equator but gains in northern latitudes, complicating the idea that particular asset classes are uniformly vulnerable. This suggests that incorporating heterogeneity in climate risk generates different coalitions depending on geography.

A caveat is that the theory rests on its model of climate change. Some may worry that global warming is a civilization-ending event. If true, then cleavages may not form, as all actors are bargaining under the shadow of existential catastrophe and may overcome incentives to not cooperate. However, even the worst case forecasts by the IPCC do not portend the collapse of civilization, although there is likely to be immense human suffering especially in presently poor and warm areas. Analysts of existential risk conclude that global warming will be "tough, but endurable" (Bostrom and Ćirković 2012, 282). To the extent that humanity is on the cusp of an apocalypse, the lethargic carbon abatement of governments would be especially puzzling. Though some may believe that climate change is existential, this tail-end risk is not guiding decision-making. Hence, our theory has more explanatory power given that it emphasizes a warming scenario with a higher probability of occurring. That said, we employ the most conservative version of CR's model that assumes zero mitigation and notwithstanding predicts potential improvements to productivities and amenities from higher temperatures.

5 Emerging Climate Cleavages

While we cannot directly test whether a climate war or bargain will occur, we can evaluate the main empirical implication of our theory: growing awareness of climate change leads actors that face potential damages to reduce emissions. We claim this is a general phenomenon, so we test it in the context of countries and cities. Since the effects of global warming have only recently begun to be felt, one might expect that there are no distinct patterns in carbon mitigation along the lines of climate vulnerability. This presents a formidable null hypothesis.

5.1 Countries

The country level outcome is whether nations take actions to curtail their GHG emissions. The primary lever states can use to manipulate carbon pollution is climate policies that either directly regulate emissions via caps and taxes, or indirectly incentivize cleaner energy via investment in green research and development. Accordingly, CLIMATE LAWS records the number of national climate laws in effect for a given country-year. This operationalization aligns with the standard approach in the literature (Eskander and Fankhauser 2020; Eskander, Fankhauser, and Setzer 2021; Nachmany et al. 2017; Townshend et al. 2013). The stock of laws captures the aggregate effort of states because policies can be additive and synergistic, which flows would miss. Data come from the Climate Change Laws of the World, which we subset to mitigation laws (Nachmany et al. 2017). We focus on policies rather than emissions because a plethora of external factors ranging from population, economic activity, natural carbon sinks, and innovation influence carbon pollution (Harrison and Sundstrom 2010; Mildenberger 2020).

One might wonder if climate laws are shallow commitments, halfheartedly enforced by governments and watered-down by interest groups (Stokes 2020). If true, climate policies should have no effect on emissions. While plausible in individual cases, Eskander and Fankhauser (2020) find that on average an increase in the stock of climate laws corresponds with lower carbon emissions in subsequent years. We perform an equivalent test, regressing the lagged stock of climate laws on an index of emissions outcomes, which similarly shows successful carbon mitigation following an expansion of policies (Online Appendix C). This suggests that while some laws may lack credibility, on average they are meaningful steps to curtail emissions.

Figure 2 plots the spatial and temporal distribution of climate laws. The progression from the top panels to the bottom shows that climate policy-making begins to ramp up in the early 2000s. As of 2020, most nations have adopted at least one mitigation law, with the greatest increase in activity occurring in Central America, South America, Oceania, Southern Europe, and parts of Africa. From a descriptive standpoint, without adjusting for such factors as state capacity, the Global South appears to be more aggressive on climate change than contemporary accounts would suggest. Parts of Central Africa lag in absolute terms, but their pace of climate mitigation activity is increasing in recent years, consistent with our theory.

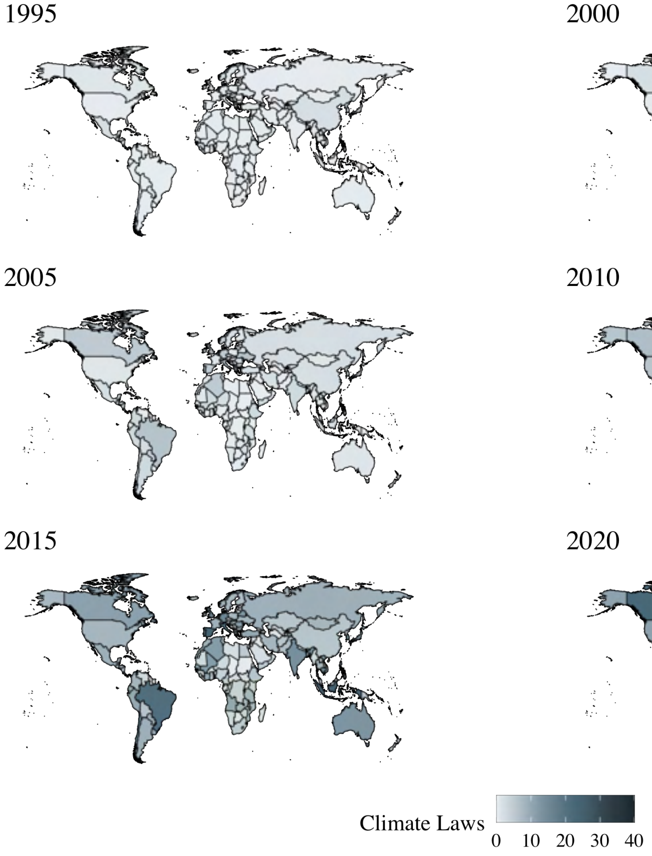

Figure 2: Expanding stock of climate mitigation laws. Data from Nachmany et al. (2017).

We use global surface temperature anomalies to measure increasing awareness of climate change. Heat anomalies are a salient indicator of global warming that humans experience on a daily basis and intuitively understand. While global warming will also cause more extreme colds, people mistakenly fail to associate cold spells with climate change, so we limit the measure to the clearest signal (Hoffmann et al. 2021; Marlon et al. 2021). Data come from the NASA Goddard Institute for Space Studies and cover nearly the entire globe with positive land mass from 1960s onward (Lenssen et al. 2019). Anomalies are measured relative to a 1951-1970 base period, with observations recorded on a $2^\circ \times 2^\circ$ grid. For each country-year, we sum the monthly temperature anomalies. This aggregation assumes people draw inferences about the changing climate from an accumulation of experiences, which is consistent with survey research finding that long-run fluctuations are significant predictors of climate beliefs (Deryugina 2013). There is no risk of post-treatment bias because present emissions reductions lag far behind future temperature changes.

Figure 3 illustrates the distribution of HEAT ANOMALIES across time and space. The plot contrasts temperature anomalies during the base period with the present. In 1963, few areas of the world experienced abnormal temperature. An obvious effect of climate change revealed by the right-hand panel is that heat anomalies accelerate. Yet there is still meaningful variation in the location of heat fluctuations due to stochastic natural processes.

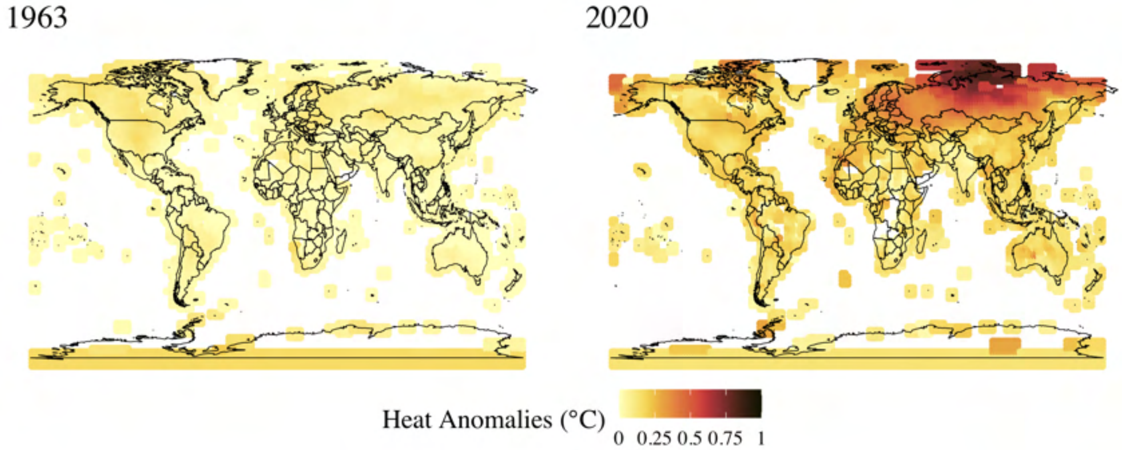

Figure 3: Distribution of heat anomalies as global warming accelerates over six decades. Data from NASA GISS (Lenssen et al. 2019).

To measure the moderating effect of potential climate damages and benefits, we construct two POTENTIAL DAMAGES indicators for if a country experiences net losses in productivities or amenities. This dichotomization is consistent with our theory of a sharp political cleavage forming. CR's model results are at the $1^\circ \times 1^\circ$ level, which we aggregate to the country-level, adjusting each cell by its population share.

Both the moderator and the explanatory variable are exogenous to the stock of national climate policies, which enhances causal leverage. Whether a country faces potential net damages or benefits depend on apolitical and fixed geographic factors such as latitude and coastline. Likewise, temperature changes are in part the consequence of stochastic processes.

A potential concern is that HEAT ANOMALIES and POTENTIAL DAMAGES are correlated, since CR estimate the damage functions using temperature data. However, this is unlikely because CR use decadal *averages* to capture the long-run effects of temperature, whereas HEAT ANOMALIES records the aggregate of monthly standard deviations in temperatures above a historical benchmark. Examining the Pearson correlation coefficient confirms that there is not a deterministic relationship ($r = -0.22$ for productivities and $r = -0.20$ for amenities). HEAT ANOMALIES correlates with lower long-term damage, a relationship not consistent with positive co-linearity. This is not surprising because short-run temperatures abnormalities result in part from natural variability.

We estimate the following empirical model using ordinary least squares, adjusting for heteroskedastic errors and auto-correlation with a panel-corrected covariance matrix (Beck and Katz 1995):

$$Y_{it} = \alpha + \delta(HeatAnomalies_{it-1} \times PotentialDamages_i) + \mathbf{X}_{it}\theta + \eta_t + \lambda_i + \epsilon_{it}. \qquad (1)$$

Y_{it} is a nation's stock of climate laws in a year. δ is the coefficient of interest for the multiplicative interaction of HEAT ANOMALIES and the damages indicator. η_t and λ_i are year and country fixed effects to remedy potential confounding due to time-invariant omitted variables. $\mathbf{X}_{it}$ is a matrix of covariates that control for alternative explanations. To account for domestic distributional conflict, we use World Bank data on the percent of GDP from oil and coal rents, which measures the economic clout of the fossil fuel industry. Similarly, CO_2 emissions per capita captures the cost an average citizen may incur from mitigating carbon pollution, with data also from the World Bank. We deploy the Polity2 index to address institutional theories about democracy. Lastly, we include GDP per capita from the World Bank as a proxy for state capacity that may be necessary to implement complex climate laws, in addition to influencing the cost of adaptation. Absent from here is a strategy to evaluate the collective action problem, which we explicitly model in section 5.2.

Figure 4 plots the marginal effect of HEAT ANOMALIES moderated by POTENTIAL DAMAGES on the stock of national climate laws. The plot shows that as countries update their beliefs in response to extreme heat, nations facing climate damages are more likely to increase their stock of climate laws compared to those experiencing net gains. The heat anomalies data are right-skewed, but there are enough observations to produce meaningful estimates with support along the explanatory variable as denoted by the marks on the x-axis. We trim some of the outliers in the tail to avoid invalid extrapolation. A robustness check excludes additional observations and the results obtain (Online Appendix F).

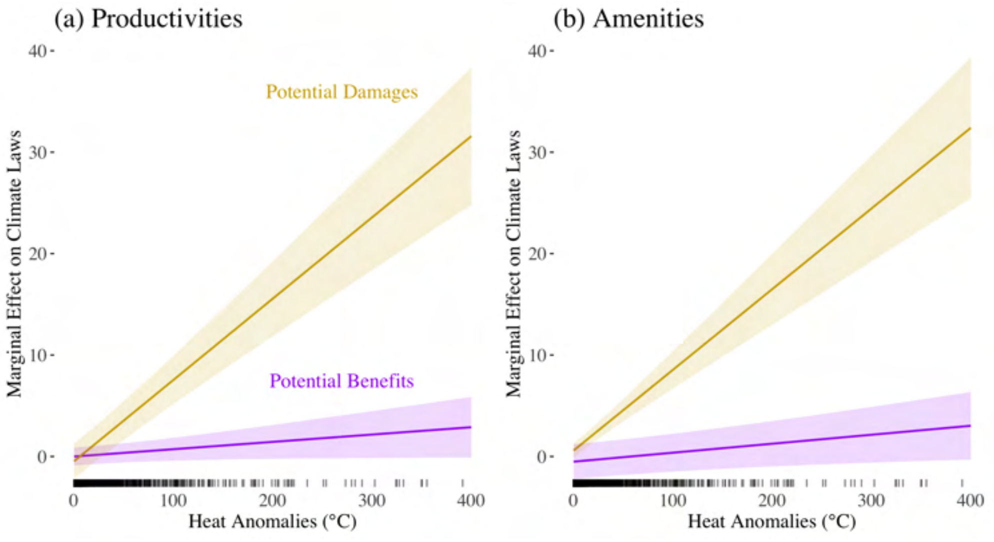

Figure 4: Marginal effect heat anomalies on the stock of national climate laws, conditional on potential climate damages, 1972-2018. Shaded bands denote 95% confidence intervals.

Table 1 presents the full results of estimating (1). The first two columns define potential climate damages and benefits in terms of productivities, while the final columns consider amenities. Across both metrics, the interaction term, HEAT ANOMALIES × POTENTIAL DAMAGES is positive and significant ($p < 0.001$). Models (1) and (3) show the coefficients for the constituent terms without the interaction included in the specification. HEAT ANOMALIES by themselves have a positive effect on climate policy enactment across all models ($p < 0.001$).

As expected, the net damages coefficient lacks significance, emphasizing that the theorized relationship depends on the informational mechanism. Potential damage on its own is insufficient to compel actors to mitigate emissions absent awareness of how global warming will likely affect them. This is especially true because many countries that face damages are poorer and lack technical capacity to implement climate policy. In consequence, there must be a meaningful signal about global warming's harms to push these nations to act due to shifts in public opinion or interest group lobbying.

There are mixed results for domestic distributional politics. OIL RENTS has a significant and negative correlation ($p < 0.01$). This would suggest that for petro-states such as Saudi Arabia, short-term considerations like economic stability matter more than underlying vulnerability. However, outside of this edge case, a triple interaction term of OIL RENTS, HEAT ANOMALIES, and POTENTIAL DAMAGES reveals that across the most common levels of oil rents, countries facing losses in amenities and productivities react to heat anomalies by increasing their stock of climate laws (Online Appendix E). This indicates that nations may care more about underlying exposure to climate damage than the strength of fossil fuel interests as the effects of global warming manifest.

For COAL RENTS, there is surprisingly a positive and significant coefficient ($p < 0.001$). This is likely a false positive, since it does not appear in subsequent models that account for the interdependence of actors. Though examining the triple interaction term, as with oil above, countries still respond to HEAT ANOMALIES depending on whether they experience POTENTIAL DAMAGES, regardless of the level of COAL RENTS. This suggests that climate hazards are driving this result, not economic self-interest, an outcome the standard distributive politics framework does not predict. To provide more intuition, we examine a selection of countries that have high coal rents but also enacted climate policies. A majority of states with high coal rents – Mozambique, South Africa, India, Indonesia, Australia, and Columbia – also face net productivity and amenities damages, lending support to this interpretation (Online Appendix D).

Table 1: Regression of the stock of national climate mitigation laws on the interaction of heat anomalies and potential climate damages, 1972-2018

	Productivities:		Amenities:	
	(1)	(2)	(3)	(4)
Heat Anomalies$_{t-1}$ × Potential Damages		0.073***		0.071***
		(0.007)		(0.006)
Heat Anomalies$_{t-1}$	0.018***	0.007***	0.018***	0.009***
	(0.001)	(0.001)	(0.001)	(0.001)
Potential Damages	−0.413	−0.460	1.219	1.100
	(0.791)	(0.772)	(0.709)	(0.687)
GDP per capita	0.008***	0.008***	0.008***	0.008***
	(0.000)	(0.000)	(0.000)	(0.000)
Polity2	0.031***	0.032***	0.031***	0.030***
	(0.006)	(0.007)	(0.006)	(0.006)
Coal Rents	0.098***	0.095***	0.098***	0.084***
	(0.013)	(0.012)	(0.013)	(0.014)
Oil Rents	−0.012**	−0.011*	−0.012**	−0.012*
	(0.005)	(0.005)	(0.005)	(0.005)
CO_2 per capita	0.650	−0.515	0.650	0.010
	(1.183)	(1.129)	(1.183)	(1.183)
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Countries	144	144	144	144
Years	46	46	46	46
Adjusted R^2	0.708	0.711	0.708	0.711
N	5607	5607	5607	5607

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$. Panel-corrected covariance matrix with errors clustered by country. CO_2 and GDP per capita scaled by 100 for exposition.

5.2 Collective Action

The country-level results suggest that nations are not taking advantage of the emissions reductions of others, but a thorough test of the free riding hypothesis requires modeling the interdependence of national climate policies. There is initial evidence that international factors (Fankhauser, Gennaioli, and Collins 2015) and policy diffusion (Kammerer and Namhata 2018) influence the passage of climate laws in other countries, but these models do not directly account for whether the actor mitigating emissions is pivotal for overall carbon pollution. Being pivotal matters because it influences the probability the public good is provided if an actor defects.

We employ a spatial model that accounts for interdependence in terms of actors' relative contributions to global warming, which captures the intensity of incentives to free ride. At the heart of spatial models is a $n \times n$ matrix, W, that measures the connectivity of units. Accompanying W is ρ, the spatial dependence coefficient that reveals the strength and direction of units' influence on each other. We specify three Ws to assess different dimensions of the collective action problem.[6] The first W records if a dyad of states contains one of the top five carbon polluters. Large nations reducing pollution may free up the global carbon budget for smaller states to free ride. The second W uses the inverse of the ratio of carbon pollution between countries in a year as the distance measure. Nations may care most about the climate policies of countries with higher levels of pollution relative to themselves since those high emitting countries have the greatest ability to influence emission levels. If collective action dynamics structure climate politics, these Ws should yield a negative ρ, since emissions abatement by the largest polluters allow the remaining countries to continue along a business-as-usual pathway.

The final W uses the inverse of the distance between national capitals to investigate the effect of reciprocity (Gleditsch and Ward 2001). Canonical work in international relations identifies reciprocity as a strategy to facilitate cooperation (e.g. Axelrod 1984). Though

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[6] All W are row standardized for computational reasons and to ensure comparability.

capital distance is a standard approach, it is not a direct measure of reciprocity, which would require a tally of states' previous interactions. Rather, the metric captures structural features that lengthen the shadow of the future by increasing the probability of repeated interactions. Countries should be less likely to free ride when their close neighbors enact climate policies since doing so might have consequences in other areas of cooperation due to the interdependence of commitments (Keohane 1984). A non-negative ρ would suggest that reciprocity reduces free riding incentives.

We use techniques from Chaudoin, Milner, and Pang (2015) to estimate a spatial model with a time-varying spatial autoregressive coefficient. Allowing ρ to differ across time is essential since the physical effects of climate change are increasingly coming into focus, altering the incentives of countries. Due to the model's complex structure, we employ a Bayesian approach using Markov chain Monte Carlo (MCMC) simulations as a numerical technique to integrate the posterior distribution with respect to the parameters. We specify uniformative priors so inferences are based primarily on the data. The empirical model takes the following form:

$$Y_{it} = \rho_t W_t \mathbf{Y}_t + \delta(HeatAnomalies_{it-1} \times PotentialDamages_i) + \mathbf{X}_{it}\theta + \epsilon_{it} \tag{2}$$

The explanatory variables and matrix of covariates are the same as in (1). The only alteration pertains to the coverage of the data, which we restrict to post-1995 to maximize complete observations that ensure a balanced panel. We employ year and time fixed effects to account for possible latent confounders.

Table 2 displays the results of estimating (2). Online Appendix H presents diagnostics that verify MCMC convergence. Turning to the spatial component of the model, the posterior mean $\bar{\rho}_t$ is negative and significant. At first cut, this is indicative of collective action dynamics. However, this average masks important changes over time. Panels (a) and (b) of figure 5 plot the posterior ρ_t for each period from 1995 through 2018 for productivities and amenities specifications. A stark trend emerges: the salience of free riding declines over time and even reverses in the 2010s. While free riding may have accurately described climate politics in the 1990s, states are increasingly likely to act even when large polluters do not. These coefficients are most precisely estimated in recent years because a greater number of countries have implemented climate policies.

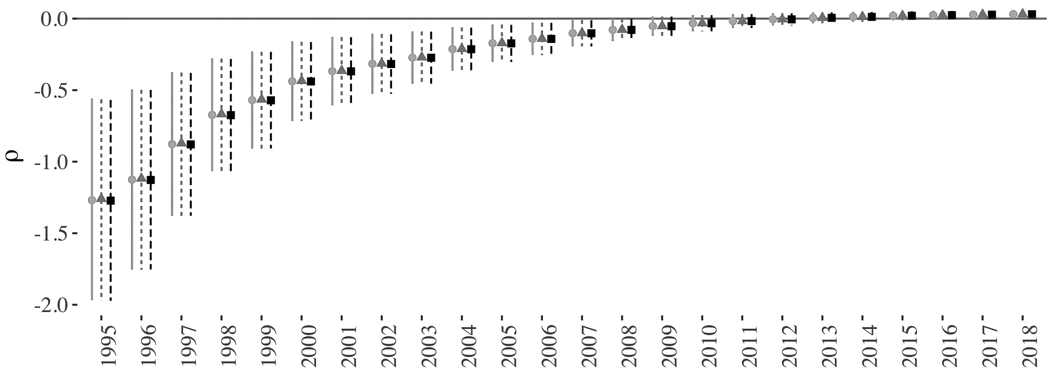
Table 2: Spatial model of the collective action problem, 1995-2018

	Productivities:			Amenities:		
	(1)	(2)	(3)	(4)	(5)	(6)
$\bar{\rho}_t$	−0.276	−0.275	−0.273	−0.271	−0.272	−0.267
	(0.113)	(0.113)	(0.112)	(0.114)	(0.114)	(0.113)
Heat Anomalies$_{t-1}$ × Potential Damages	0.001*	0.001*	0.001*	0.001*	0.001*	0.001*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Heat Anomalies$_{t-1}$	0.005	0.005	0.005	0.006	0.006	0.006
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Potential Damages	−0.421	−0.421	−0.428	−0.654	−0.653	−0.656
	(0.447)	(0.448)	(0.446)	(0.427)	(0.428)	(0.430)
GDP per capita	0.007*	0.007*	0.007*	0.007*	0.007*	0.007*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Polity2	−0.009	−0.009	−0.009	−0.011	−0.011	−0.011
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Coal Rents	0.074	0.074	0.074	0.078	0.078	0.078
	(0.064)	(0.064)	(0.064)	(0.064)	(0.064)	(0.064)
Oil Rents	−0.035*	−0.035*	−0.035*	−0.034*	−0.034*	−0.034*
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
CO2 per capita	−0.087*	−0.087*	−0.087*	−0.09*	−0.09*	−0.09*
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
Countries	131	131	131	131	131	131
Years	24	24	24	24	24	24
N	3144	3144	3144	3144	3144	3144

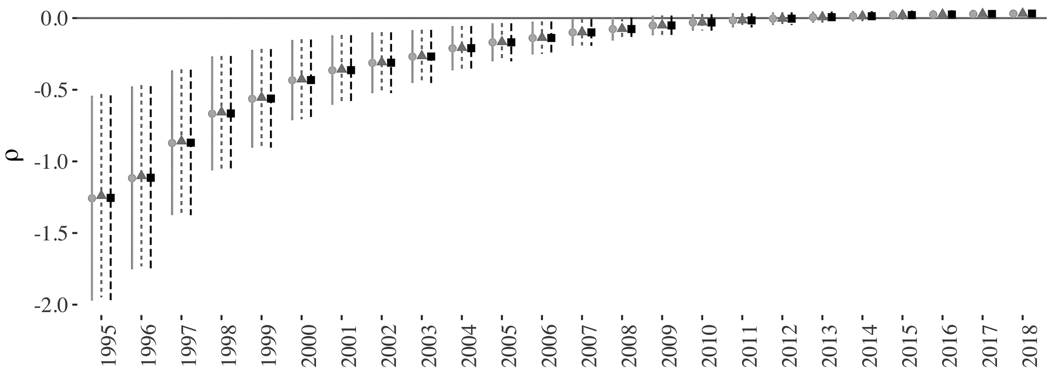
*95 percent credible interval excludes 0. GDP PER CAPITA scaled by 100 for exposition. Models (1) and (4) correspond with the top polluters W, (2) and (5) with relative emissions, and (3) and (6) with geographic proximity. Total of 50,000 MCMC iterations with 5,000 burn-in and thinning parameter of 150.

Why is free riding receding? We contend that increasing awareness of vulnerability to climate change is altering expected payoffs such that incentives to cooperate overwhelm the marginal benefit of defection for countries facing damages. The interaction term between

(a) Productivities



(b) Amenities



(c) Heat Anomalies

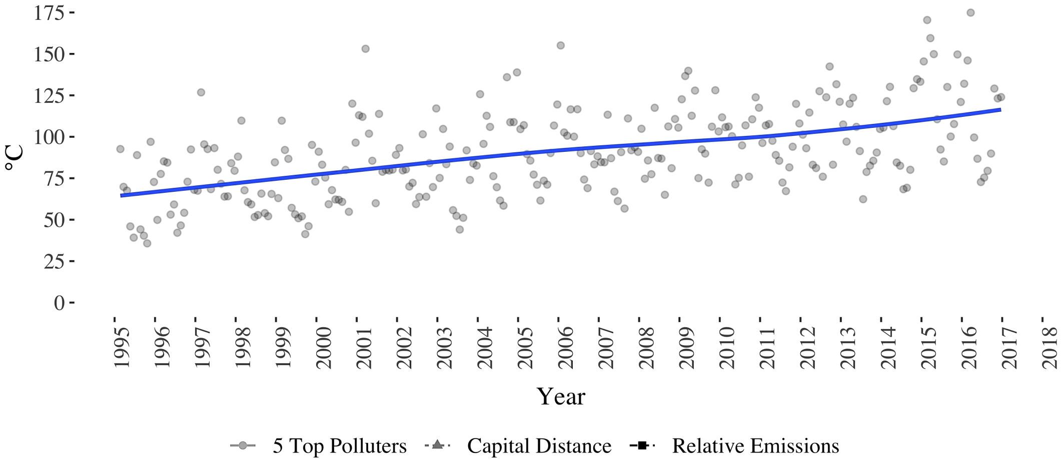


Figure 5: Panels (a) and (b) plot the time-varying posterior ρ_t across different W specifications, 1995-2018. Bars denote 95% credible intervals. Panel (c) shows a LOWESS line tracking the increase in heat anomalies that occurs alongside the receding collective action problem.

HEAT ANOMALIES and POTENTIAL DAMAGES is positive and significant across all models ($p < 0.001$), lending support to our claim. Further, panel (c) of figure 5 shows that this occurs alongside the most significant increase in heat anomalies since the pre-industrial period. Though this may be spurious, our model controls for the most likely sources of confounding. This also suggests that as climate change occurs and everyone updates their beliefs about global warming, adversely impacted countries weigh it more heavily in their interactions, making reciprocity and interdependence stronger constraints.

The findings here differ from previous critiques of the free riding hypothesis. While Aklin and Mildenberger (2020) argue that free riding is not necessary to explain variation in climate policy, our results show that free riding *was once salient* but is much less so because of changing perceptions of global warming's costs and benefits.

5.3 Cities

Having shown that a climate cleavage is emerging between countries, does this relationship manifest at different levels of analysis? This section turns to cities to provide an external test of our theory. Cities are growing political centers of power, with an estimated 60 percent of the world's population projected to live in urban areas by 2030 (United Nations 2020). Cities contribute to a considerable share of global emissions, consuming 78 percent of the world's energy and producing over 60 percent of carbon pollution.[7] Given their out-sized contribution to climate change, cities are increasingly engaging in sub-national diplomacy to exchange information about clean energy technologies and urban planning for adaptation (Tavares 2016).

Figure 6 shows the spatial distribution of cities and whether they reported climate actions to CDP from 2012 to 2020. CDP is a non-profit that aims to create transparent and uniform climate reporting standards for cities and firms. Each year, the organization solicits cities for information on their emissions, climate actions, and climate risks. We focus on reported

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[7] https://www.un.org/en/climatechange/climate-solutions/cities-pollution

emission reduction activities because they are tangible steps to curtail pollution. To avoid selection bias, we construct a comprehensive list of 42,687 cities using the `maps` package in R, a standard tool for geospatial analysis. We pair this vector of cities with the CDP reports via a reproducible fuzzy matching procedure.[8] We manually checked ambiguous matches to reduce measurement error.[9] Using this data, we construct an indicator for if a city reports climate actions to CDP. We use a binary outcome rather than the number of actions reported since the latter likely reflects greater bureaucratic capacity and lacks comparability across units.

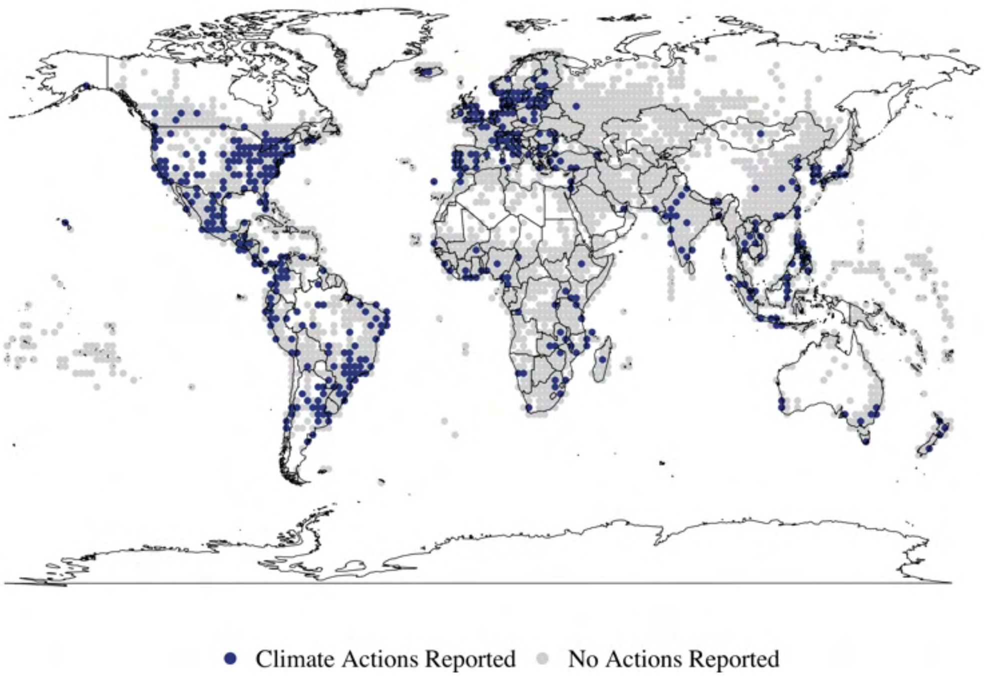

Figure 6: City reporting of climate actions, 2012-2020

A potential source of measurement bias is that cities may be unaware of CDP and would have reported otherwise. While plausible, CDP has offices in every continent and actively solicits participation, which makes it likely that cities know of the program. CDP is also a touchstone resource on how local governments can implement climate policies, so cities

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[8] Cities included are those with a population greater than 40,000, capital cities, and some towns.

[9] The few cities that remain unmatched tend to be located in Latin America and the Caribbean, which biases against our hypothesis since these areas face potential damages (Online Appendix I).

exploring emissions mitigation are likely to come across the organization through cursory research. Thus, unaware municipalities are unlikely to be those seeking to mitigate pollution. Moreover, cities have incentives to participate. First, information provided by the network yields cost savings. Second, leaders may receive a political benefit, since CDP signals the politician's environmental commitment to climate-minded constituents. Third, CDP acts as a credible third party to vet sustainability information cities share, which helps raise capital from the growing pool of sustainability-driven investors.

Turning to the explanatory variable, we employ the same weather data as before, but pair it with the coordinates of cities. For the moderator, we match CR's model results to cities, classifying them as experiencing POTENTIAL DAMAGES in terms of amenities or productivities. Note that we drop the *net* prefix because cities fall within discrete geographic locations that experience either absolute gains or losses from temperature in terms of amenities and productivities.

We estimate a hierarchical model because it best captures the dynamics of city climate reporting. Cities reside within countries with common characteristics that influence the latitude local governments have to implement climate policies. Specifically, we employ a model with random intercepts for cities and countries, estimated via restricted maximum likelihood with the `lme4` package in R.

To control for distributive politics explanations, we leverage satellite recordings of gaseous and particulate air pollutants, which proxy for the strength of incumbent fossil fuel interests. The data are recorded at the $0.1° \times 0.1°$ resolution for sub-sectors, so we can precisely pair them with cities and disaggregate the relative importance of sectors.[10] We use principal components analysis to construct indices for the POWER SECTOR, OIL SECTOR, and MANUFACTURING SECTOR that measure the level of pollution produced by each. Data reduction avoids collinearity in emissions.[11] In addition, we record the level of CO_2 emissions for each

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[10] We aggregate the data to the $1° \times 1°$ level for computational efficiency.

[11] The data track the following air pollutants: BC, CO, NH_3, NMVOC, NO_x, OC, PM_{10}, $PM_{2.5}$, and SO_2. The first eigenvector explains 65 percent of the variation in the power sector, 70 for oil, and 85 for manufacturing.

city using satellite measurements. Data for the above come from the Emissions Database for Global Atmospheric Research (EDGAR) (Crippa et al. 2020; Crippa et al. 2018). To avoid post-treatment bias, we record the average of level of pollution in the five years prior to the start of the panel. Substantively, these measures capture the strength of polluting interests and the costs of mitigating emissions. They also proxy for population size, since larger cities, all else equal, likely have higher levels of pollution. Although we include a control for the log of population, the quality of this measure from `maps` is lower than the satellite data.

To account for the flexibility that local governments have to implement policy independent from the central government, we control for FEDERALISM with the V-Dem local government index (v2xel_locelec). Low scores suggest that countries have no elected local governments, whereas high scores indicate that local governments are elected and can operate without restrictions from un-elected actors save for judicial bodies. Federalism should have a positive correlation with city climate disclosures.

While these variables address the most obvious sources of confounding, there could be other culprits. We take three precautionary steps to minimize this threat to inference. First, to take care of system-wide effects and temporal trends, such as increasing awareness of CDP, we include year fixed effects. Second, the random intercepts capture some time-invariant confounding because the random effects estimator is a weighted combination of within and between estimators.[12] Third, the hierarchical model provides some traction in taming omitted variable bias by partitioning the variance so confounders at the country level do not contaminate predictors at the city level.

Figure 7 plots the marginal effects. The relationship found among countries also appears among cities; cities that experience heat anomalies are more likely to report climate actions if they face potential damages, but not otherwise. Table 3 presents the results from estimating the hierarchical model.[13] The coefficient on the interaction term is positive and significant

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[12] We use random effects due to efficiency gains and the theoretical expectation of meaningful inter-city variation. Efficiency is not trivial. With 42,687 cities, adding a fixed effect for each would proliferate nuisance parameters.

[13] To evaluate goodness-of-fit, we conduct likelihood ratio tests that compare each specification against a

in both specifications ($p < 0.001$). As with countries, the effect of potential damages depends on updating through observed heat anomalies, which is why the partial derivative for POTENTIAL DAMAGES is negative when HEAT ANOMALIES is set to 0.

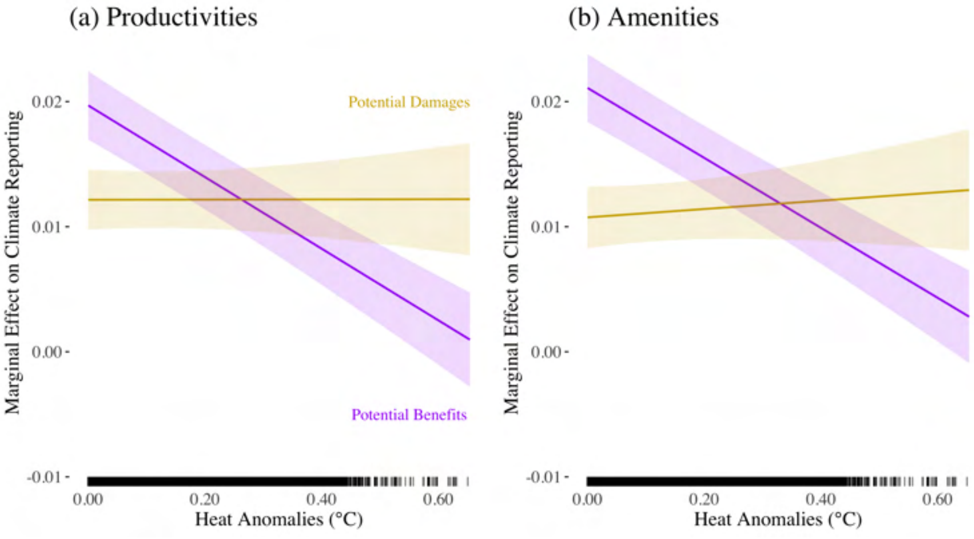

Figure 7: Marginal effect of heat anomalies moderated by potential damages on city climate reporting, 2012-2020. Shaded bands denote 95 percent confidence intervals.

The covariates provide mixed evidence for the standard distributive politics model. In support, the coefficients for MANUFACTURING SECTOR ($p < 0.001$) and POWER SECTOR ($p < 0.05$ in 2 of 4 models) are negative and significant. This suggest that industrial cities home to manufacturing and those reliant on inefficient electricity generation are less likely to report pro-climate actions. Curiously, the coefficient for OIL SECTOR is positive across all models ($p < 0.001$). This may be because these emissions are from oil refineries, which tend to be located along coastal regions with access to shipping routes. These cities are thus exposed to climate damage from sea level rise and have a vulnerable citizenry that support pro-climate mayors. For example, municipalities along the coast of California have taken actions to combat climate change while simultaneously are home to oil refining operations.

Other coefficients have their expected signs: FEDERALISM is positive and significant across three of four models ($p < 0.05$); capital cities and those with larger populations are

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null model that excludes our interaction term of interest. We can reject the hypothesis that the null model provides as good a fit for the data as the more complex model ($p < 0.001$).

more likely to report climate activities ($p < 0.001$). The latter findings suggest that capacity is an important determinant of city climate policy.

Table 3: Hierarchical model of city climate reporting, 2012-2020

	Productivities:		Amenities:	
	(1)	(2)	(3)	(4)
Heat Anomalies$_{t-1}$ × Potential Damages		0.0003^{***}		0.0003^{***}
		(0.0000)		(0.0000)
Heat Anomalies$_{t-1}$	-0.0002^{***}	-0.0003^{***}	-0.0002^{***}	-0.0003^{***}
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Potential Damages	-0.0029^{**}	-0.0075^{***}	-0.0056^{***}	-0.0103^{***}
	(0.0010)	(0.0012)	(0.0011)	(0.0013)
Capital	0.0804^{***}	0.0805^{***}	0.0804^{***}	0.0804^{***}
	(0.0027)	(0.0027)	(0.0027)	(0.0027)
CO_2	0.0149	0.0185	0.0033	0.0073
	(0.0690)	(0.0690)	(0.0690)	(0.0690)
Population (log)	0.0087^{***}	0.0087^{***}	0.0087^{***}	0.0087^{***}
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Federalism	0.0036^{*}	0.0040^{*}	0.0034	0.0037^{*}
	(0.0018)	(0.0018)	(0.0018)	(0.0018)
Power Sector	−0.0003	−0.0003	-0.0003^{*}	-0.0003^{*}
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Oil Sector	0.0008^{***}	0.0008^{***}	0.0008^{***}	0.0008^{***}
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Manufacturing Sector	-0.0010^{***}	-0.0010^{***}	-0.0010^{***}	-0.0011^{***}
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
City Intercept Variance	0.0026	0.0026	0.0026	0.0026
Country Intercept Variance	0.0001	0.0001	0.0001	0.0001
Year FE	Yes	Yes	Yes	Yes
Cities	42687	42687	42687	42687
Countries	155	155	155	155
N	382914	382914	382914	382914
Conditional R^2_{GLMM}	0.4535	0.4535	0.4532	0.4534
Log Likelihood	487869	487891	487878	487902
Residual	0.0037	0.0037	0.0037	0.0037

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$. Random intercepts for cities nested within countries.

6 Updating in Response to Heat Anomalies

The previous sections demonstrated that countries and cities respond to extreme heat by mitigating carbon emissions, if they face climate damages. This finding, though suggestive, does not test the hypothesized mechanism that observed climatic variability increases awareness of global warming's effects, which translates into policy (in)action. If this information updating mechanism holds, individual attitudes about the severity of climate change should mirror the country and city interaction effects. As theorized above, we expect larger effects for amenities because they are more observable than productivities and hence of greater salience.

Individual attitudes matter for the policy outcomes. In responsive political regimes, if people express greater worry about climate change, they are more likely to act on their preferences by voting for pro-climate leaders (Hoffmann et al. 2021). Even autocratic regimes may exhibit representation within bounds if the issue is nonsensitive to the government's core interests (Truex 2016). Outside of representation, a burgeoning literature shows how leaders may take their cues from the bottom-up (Kertzer and Zeitzoff 2017) and how elites perceive events in similar ways as the mass public (Kertzer 2020). Thus, in addition to the direct channel of the public influencing outcomes, we can also interpret individual attitudes as indicative of how leaders might update in response to heat anomalies.

While there is limited cross-national panel data on climate attitudes, there are disparate questionnaires fielded across countries at different points in time. We leverage two such polls to provide a snapshot of how attitudes about global warming vary in response to our theorized information mechanism. We hypothesize that the effect of temperature anomalies on concern about climate change should be strongest when individuals hold weak priors about global warming. As people experience more anomalous weather, they develop stronger priors and place less weight on new information. We use the fifth wave of the World Values Survey (WVS) fielded in 2005-2009 to assess how people respond to heat anomalies in a *weak prior* information environment. Then we use Gallup's 2019 World Risk Poll to re-assess the same relationship in a *strong prior* setting. People likely have stronger priors during this period because the NASA GISS data show that the last decade has been the hottest on record compared to the pre-industrial baseline. Indicative of the widening scope of global warming's observable effects, Callaghan et al. (2021) find that 85 percent of the population may have been be exposed to climate impacts attributable to human emissions. Although there remains room for climate awareness to increase.

We select these surveys due to their geographic coverage and similar questions. The WVS asks:

> Now let's consider environmental problems in the world as a whole. Please, tell me how serious you consider each of the following to be for the world as a whole. Is it very serious, somewhat serious, not very serious or not serious at all? Global warming or the greenhouse effect.

The Gallup World Risk poll asks:

> Do you think that climate change is a very serious threat, a somewhat serious threat, or not a threat at all to the people in this country in the next 20 years? If you do not know, please just say so.

The questions have slight differences, but are comparable. We dichotomize this measure by coding "very serious" from WVS and "very serious threat" from Gallup as 1 and the rest as 0. This ensures appropriate variation, since many respondents say they are concerned about climate change (Kennard 2021).

One might wonder if expressed concern about global warming translates into costly political behavior, such as supporting higher fossil energy taxes. While we cannot alleviate this limitation entirely, Kennard (2021) demonstrates that answers to the WVS item correlate with credible behavioral outcomes such as internet searches to learn more about climate change.

Since the outcome is dichotomous, we employ logistic regression of individual concern about climate change on the interaction of HEAT ANOMALIES and POTENTIAL DAMAGES. We employ lagged heat anomalies data because some surveys may have been conducted near year's end. Both surveys do not record the geo-location of respondents, so we use the country level damage indicators. This introduces ecological concerns that we cannot completely resolve but can patch in part by weighting the damage variable by share of population at the cell-level.

The exogenous nature of HEAT ANOMALIES and POTENTIAL DAMAGES lends a causal interpretation to our coefficients, assuming we account for potential bias from omitted variables. To rule out confounding, we employ the standard set of individual-level covariates for age, income, gender, and college education. Additional country-level covariates adjust for coal and oil rents as a percent of GDP, in addition to GDP and CO_2 per capita. To test whether the mechanism applies at the city level, we include an indicator for if the respondent resides in an urban area.

Figure 8 presents the marginal effects of the interaction term in the *weak prior* setting.[14] Concern about global warming increases for respondents in countries with more extreme weather, if they face potential damages. However, this effect does not appear in nations with few heat anomalies. As expected, updating is strongest in the amenities specification. While these are inter-state comparisons, this pattern provides support for the informational mechanism. We caution against extrapolating the marginal effects on the far right of the plot, where there is less common support along the explanatory variable, although each cluster of hashes along the x-axis represents a considerable number of respondents within a single country. We add mean-zero noise to the hashes to emphasize this distribution.

Figure 9 provides evidence that this relationship attenuates as individual priors strengthen in response to an accumulation of extreme heat exposure. This is visible in the slopes of the marginal effects lines, which flatten due to greater weight being placed on the prior. However, information updating still persists for amenities, likely due to the salience of amenities and room for awareness of climate change to increase.

These results contradict the standard narrative that individuals in the Global North

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[14] Online Appendix J contains the regression table.

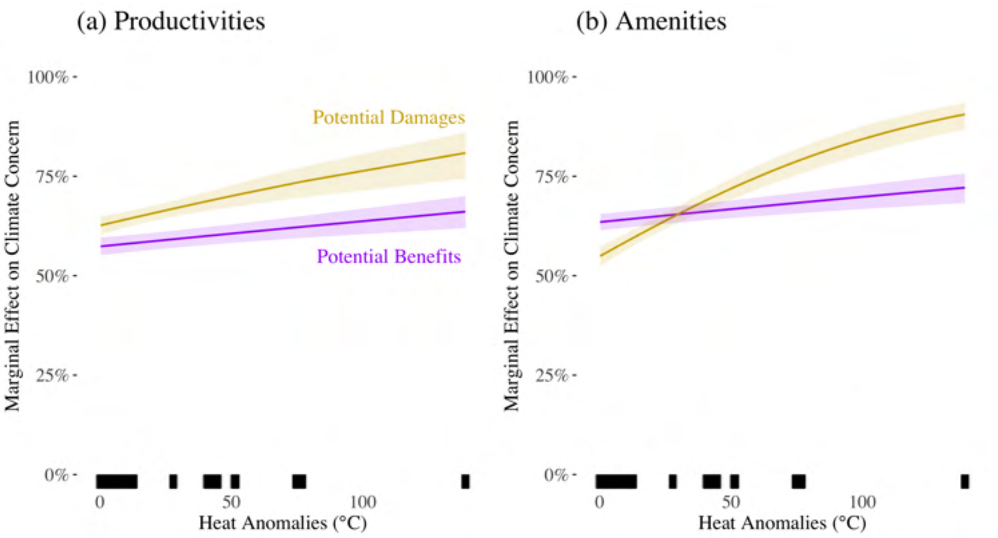

Figure 8: Updating with weak priors – marginal effect of heat anomalies moderated by potential damages on individual concern about global warming. Data from WVS. $N = 20110$ respondents in 38 countries. Shaded bands denote 95 percent confidence intervals. Marginal effects on the left of the plot have the strongest support.

are most worried about climate change. When holding relevant factors constant, such as education and income, individuals in the South after having been exposed to extreme heat anomalies express relatively greater concern in line with the damages they face.

To evaluate how these public attitudes map onto the city results, we examine a triple interaction between an indicator for urban residence, HEAT ANOMALIES, and POTENTIAL DAMAGES. Ceteris paribus, urban respondents are more concerned about climate change ($p < 0.001$). This lends support to our claim that cities may be motivated to disclose climate actions to CDP out of constituent pressure. Figures in Online Appendix K show a similar pattern for rural and urban areas: respondents in locations experiencing net damages are more concerned about climate change. However, the baseline effect shifts upwards in urban areas, with individuals more generally expressing climate concern. This may be due to coastal city exposure to damage from sea level rise. The main point is that the results show support for the informational mechanism at the city level.

In all, there is credible evidence that individuals update their concerns about climate change in response to heat anomalies. Individuals in areas set to lose from global warming

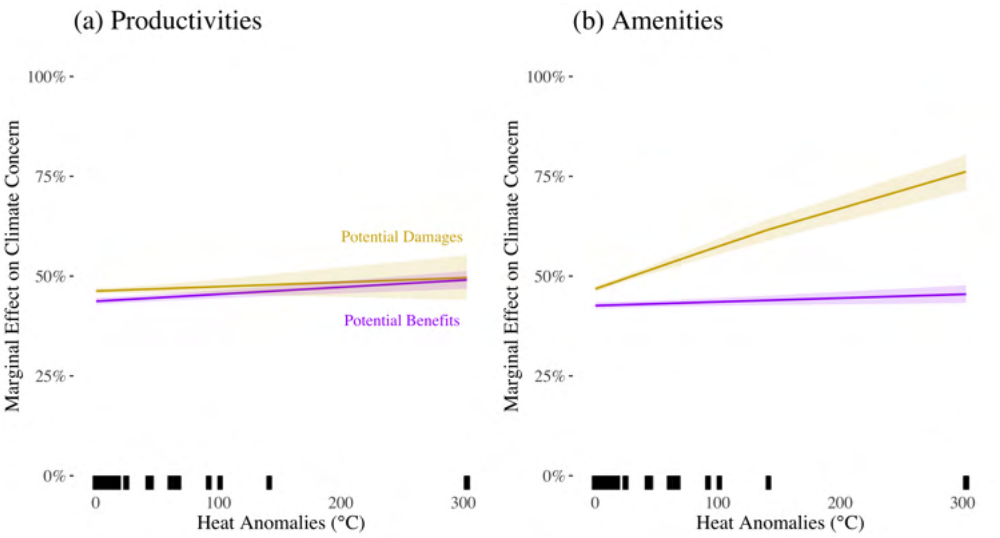

Figure 9: Updating with strong priors — marginal effect of heat anomalies moderated by potential damages on individual concern about global warming. Shaded bands denote 95% confidence intervals. $N = 157461$ respondents in 142 countries. Marginal effects on the left of the plot have the strongest support.

view climate change as more of a threat than do people in places that face potential net gains. This is consistent with an expanding literature on the relationship between hot temperature fluctuations and beliefs about climate change (e.g. Marlon et al. 2021), but differs by showing the role of underlying vulnerability to climate hazards as a moderator for where this effect obtains. Of course, these results must be interpreted with caution because they are cross-sectional. Future research could extend these findings by pairing the damages indicator with high quality panel data.

7 Conclusion

Climate change will be one of the defining events of the 21st century. It will have a profound economic and social toll, especially on actors in the Global South who are most vulnerable to the effects of higher temperatures. From a normative perspective, this warrants swift cuts to GHG emissions. However, our findings provide little cause for optimism. All else equal, countries and cities are acting in terms of their narrow self-interest, mitigating emissions if they stand to lose from global warming and polluting otherwise. Given the immense scope of the climate crisis, the political cleavage between the Global North and South will only continue to deepen and spill over into other dimensions of international relations such as trade and security.

Our theory intervenes in the debate between the collective action and distributive politics frameworks. We show how both have incompletely specified preferences due to the lack of a model of climate change's economic effects that includes the possibility of net benefits. By amending the distributive politics model to include potential gains, we generate novel predictions that free riding and the influence of incumbent interest groups, though once salient, will fade as the climate crisis intensifies.

In doing so, we provide a workhorse model of climate preferences for distributive politics that scholars can implement to answer new questions. Countries and cities are only two of a plethora of actors impacted by global warming. Extensions of this project could pair the potential damage measures with firms and civil society organizations, as we are attempting in other work. Additionally, scholars could add non-material elements to our model, such as identity, ideology, and partisanship. While we focus on the economic effects of global warming because it provides the greatest explanatory leverage, we make no pretense that it is the only factor at work. There are ripe opportunities for productive syntheses.

Another progressive line of research should examine the political cleavages that may form *within* countries in response to climate change. Global warming will have disparate effects depending on race and socio-economics, which future models of preferences should incorporate (e.g. Zucker 2021). In addition, just as the political economy of trade literature has fruitfully explored distributive effects within sectors and between firms, similar considerations could be integrated into CR's model.

In all, our theory points in a new direction for climate politics research. The physical effects of global warming will increasingly act as a structural constraint on actors, while reinforcing pre-existing inequalities between the Global North and South. To understand climate politics requires a deeper understanding of how climate change will materially affect each part of the world. Our article represents the first steps in this endeavour.

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Supplemental Online Appendix

A Description of Dynamic Economic Assessment Model

Informally, CR's model has the following set up:

- *Preferences.* Each period, agents derive utility from consumption of local amenities and idiosyncratic preferences for where they reside. Local amenities are affected by congestion due to population density, and a damage function that relates the level and change of temperature to the degradation or improvement of amenities. Agents earn income from wages and per capita land rents. Migrating to a new location reduces utility by an origin- and destination-specific mobility cost. Local natality rates are a function of a location's real income and local temperature.
- *Technology.* A dynamic process determines productivity based on shocks from the prior period's innovation decisions, effect of innovation on the production function, level of past technology, technology diffusion, and effect of temperature on local productivity. Production requires land, labor, and energy, where energy is a composite of fossil fuels and clean energy sources with the balance determined by the elasticity of substitution. The cost of fossil fuels depends on extraction costs and productivity of energy generation.
- *Prices, export shares, and trade balance.* Firms sell goods at marginal cost less the iceberg trade cost of transport. A standard gravity equation calculates the probability a good is exported from one area to another.
- *Climate and the carbon cycle.* CO_2 emissions are endogenous to fossil fuel combustion and non-fuel combustion (e.g., deforestation). The stock of atmospheric CO_2 depends on previous emissions. Global radiative forcing increases with CO_2 concentrations. Global temperature rises when the inflow of solar energy exceeds outflow. Global temperature is scaled down to local values through a linear function that accounts for the heterogeneous local characteristics such as latitude, elevation, vegetation density, albedo, distance to coast, ocean, water, etc.

These conditions define a dynamic competitive equilibrium and reduce to a location-specific system of equations for populations and wages. The spatial equilibrium then determines a firm's level of innovation, energy consumption, and carbon emissions. A carbon cycle model relates these decisions to changes in local temperatures and, as a consequence, the next period's amenities and productivities.

B Potential Climate Damages by Country

Table B1: Potential damage to amenities and productivities by country

Country	Productivity Damages	Amenities Damages
Afghanistan	1	0
Angola	1	1
United Arab Emirates	1	1
Argentina	1	1
Armenia	0	0
Antigua & Barbuda	1	1
Australia	1	1
Austria	0	0
Azerbaijan	1	0
Burundi	1	1
Belgium	0	0
Benin	1	1
Burkina Faso	1	1
Bangladesh	1	1
Bulgaria	0	0
Bahrain	1	1
Bosnia & Herzegovina	0	0
Belarus	0	0
Belize	1	1
Bolivia	1	1
Brazil	1	1
Brunei	1	1
Bhutan	0	0
Botswana	1	1
Central African Republic	1	1
Canada	0	0
Switzerland	0	0
Chile	0	0
China	1	0
Côte d'Ivoire	1	1
Cameroon	1	1
Congo - Kinshasa	1	1
Congo - Brazzaville	1	1
Colombia	1	1
Comoros	1	1
Cape Verde	1	1
Costa Rica	1	1
Cyprus	1	1
Czechia	0	0
Germany	0	0
Djibouti	1	1
Denmark	0	0
Dominican Republic	1	1
Algeria	1	1
Ecuador	1	1
Egypt	1	1
Eritrea	1	1
Spain	1	1
Estonia	0	0
Ethiopia	1	1
Finland	0	0
Fiji	1	1
France	1	0
Micronesia (Federated States of)	1	1
Gabon	1	1
United Kingdom	1	0
Ghana	1	1
Guinea	1	1
Gambia	1	1
Guinea-Bissau	1	1
Equatorial Guinea	1	1
Greece	1	1

Grenada	1	1
Guatemala	1	1
Guyana	1	1
Honduras	1	1
Croatia	0	0
Haiti	1	1
Hungary	0	0
Indonesia	1	1
India	1	1
Ireland	1	0
Iran	0	0
Iceland	0	0
Israel	1	1
Italy	1	0
Jamaica	1	1
Jordan	1	1
Japan	1	0
Kazakhstan	0	0
Kenya	1	1
Kyrgyzstan	0	0
Cambodia	1	1
Kiribati	1	1
St. Kitts & Nevis	1	1
South Korea	0	0
Kuwait	1	1
Laos	1	1
Lebanon	1	1
Liberia	1	1
St. Lucia	1	1
Sri Lanka	1	1
Lesotho	1	1
Lithuania	0	0
Latvia	0	0
Morocco	1	1
Moldova	0	0
Madagascar	1	1
Maldives	1	1
Mexico	1	1
North Macedonia	0	0
Mali	1	1
Malta	1	1
Myanmar (Burma)	1	1
Mongolia	0	0
Mozambique	1	1
Mauritania	1	1
Mauritius	1	1
Malawi	1	1
Malaysia	1	1
Namibia	1	1
Niger	1	1
Nigeria	1	1
Nicaragua	1	1
Netherlands	1	0
Norway	0	0
Nepal	1	1
New Zealand	1	1
Oman	1	1
Pakistan	1	1
Panama	1	1
Peru	1	1
Philippines	1	1
Papua New Guinea	1	1
Poland	0	0
Portugal	1	1
Paraguay	1	1
Romania	0	0
Russia	0	0
Rwanda	1	1

Saudi Arabia	1	1
Sudan	1	1
Senegal	1	1
Singapore	1	1
Solomon Islands	1	1
Sierra Leone	1	1
El Salvador	1	1
Serbia	0	0
Suriname	1	1
Slovakia	0	0
Slovenia	0	0
Sweden	0	0
Eswatini	1	1
Seychelles	1	1
Syria	1	1
Chad	1	1
Togo	1	1
Thailand	1	1
Tajikistan	0	0
Tonga	1	1
Trinidad & Tobago	1	1
Tunisia	1	1
Turkey	1	0
Tanzania	1	1
Uganda	1	1
Ukraine	0	0
Uruguay	1	1
United States	0	0
Uzbekistan	0	0
St. Vincent & Grenadines	1	1
Venezuela	1	1
Vietnam	1	1
Vanuatu	1	1
Samoa	1	1
Yemen	1	1
South Africa	1	1
Zambia	1	1

C Credibility of Climate Policy Measure

To validate the credibility of the climate laws outcome variable, we estimate the effect of the national climate policy stock in the previous year on carbon pollution in the subsequent year. Lagging the variable avoids the reverse causality problem of countries adopting legislation once it becomes economically feasible given lower GHG emissions. If policies are hallow commitments, they should have no effect on pollution levels. To measure carbon emissions, we employ a sub-index of the Environmental Performance Index (Wendling et al. 2020), a cross-national metric of environmental quality. Higher values of the index denote pro-climate emissions outcomes. Table C1 shows a positive and significant relationship exists between an increase in the stock of climate law and improvements in carbon abatement in the subsequent year ($p < 0.001$). The covariates have the expected signs, except for democracy, which is negative. This is likely because democracies tend to have bigger economies, which correlates with higher pollution. Indeed, interacting POLITY2 with GDP PER CAPITA yields a positive and significant coefficient ($p < 0.05$).

Table C1: Regression of carbon emissions intensity on the lagged stock of climate laws, 1995-2020

	Model 1	Model 2	Model 3
Climate Laws$_{t-1}$	0.837^{***}	0.820^{***}	0.727^{***}
	(0.184)	(0.181)	(0.141)
GDP per capita	0.354^{*}	-0.569	2.987^{***}
	(0.142)	(0.491)	(0.140)
Polity2	-0.839^{***}	-0.883^{***}	0.406^{***}
	(0.088)	(0.088)	(0.033)
Coal Rents	-3.587^{***}	-3.601^{***}	-0.968
	(0.770)	(0.760)	(1.066)
Oil Rents	-0.537^{***}	-0.517^{***}	-0.241^{***}
	(0.052)	(0.053)	(0.024)
Population (log)	-3.075	0.270	-1.315^{***}
	(4.020)	(3.714)	(0.107)
GDP per capita × Polity2		0.155^{*}	
		(0.067)	
Country FE	Yes	Yes	No
Year FE	Yes	Yes	Yes
Countries	160	160	160
Years	25	25	25
N	4137	4137	4137
Adjusted R^2	0.542	0.542	0.127

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$. Panel-corrected covariance matrix following Beck and Katz (1995). Errors clustered by country. GDP per capita, coal exports, and oil exports scaled by 10,000 for exposition.

D Countries with Highest Coal Rents

Table D1: Climate policies and damages for countries with coal rents exceeding 0.5 percent of GDP in 2018

Country	Coal Rents	Stock of Climate Laws	Productivity Damages	Amenities Damages
Mongolia	8.71	9.00	0	0
Mozambique	4.13	9.00	1	1
South Africa	2.40	6.00	1	1
India	1.15	15.00	1	1
Indonesia	1.08	27.00	1	1
Kazakhstan	1.05	8.00	0	0
Australia	0.79	13.00	1	1
Colombia	0.71	14.00	1	1
China	0.58	7.00	1	0
Tajikistan	0.54	6.00	0	0
Afghanistan	0.54	7.00	1	0
Russia	0.52	9.00	0	0

E Distributive Politics and Climate Damages

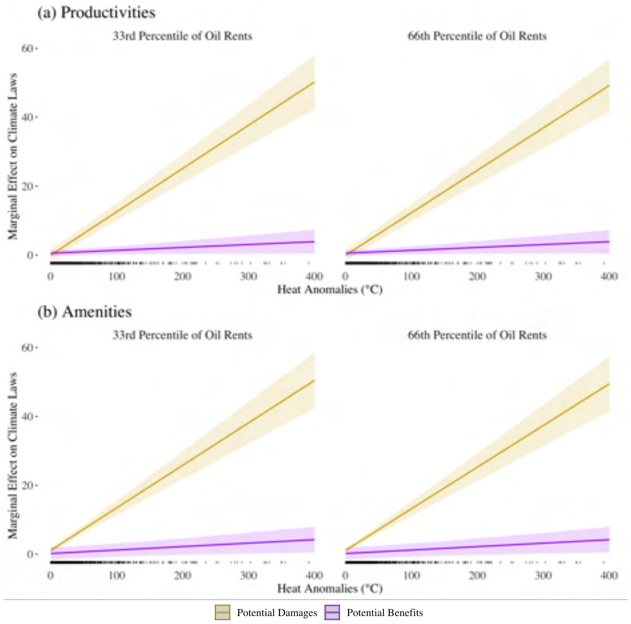


Figure E1: Marginal effects for the interaction of heat anomalies, potential climate damages, and oil rents. Shaded bands denote 95 percent confidence intervals.

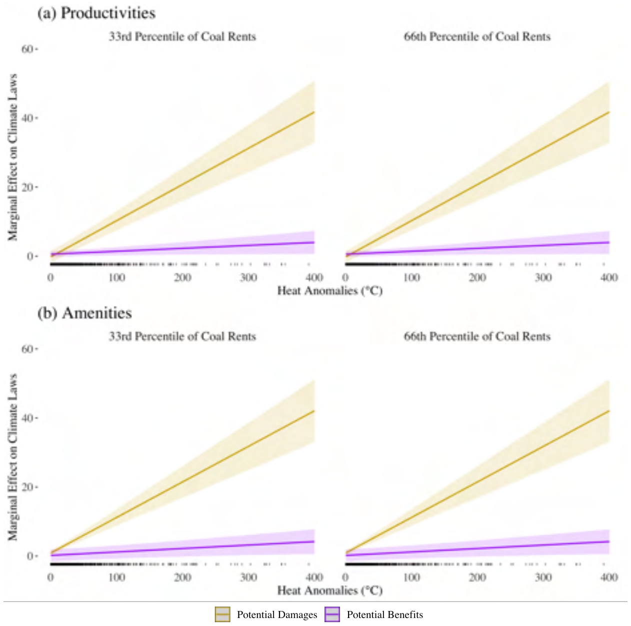


Figure E2: Marginal effects for the interaction of heat anomalies, potential climate damages, and coal rents. Shaded bands denote 95 percent confidence intervals.

Table E1: Regression of the stock of national climate laws on triple interaction terms to probe the joint effect of distributive politics and climate damages, 1972-2018

	Productivities	Amenities
Heat Anomalies	0.009^{***}	0.011^{***}
	(0.002)	(0.002)
Potential Damages	-0.734	0.711
	(0.787)	(0.720)
Oil Rents	0.008	-0.006
	(0.005)	(0.010)
Coal Rents	0.005	-0.006
	(0.020)	(0.021)
GDP per capita	0.008^{***}	0.008^{***}
	(0.000)	(0.000)
Polity2	0.033^{***}	0.031^{***}
	(0.007)	(0.006)
CO_2 per capita	-0.125	0.117
	(1.067)	(1.220)
Heat Anomalies × Potential Damages	0.114^{***}	0.106^{***}
	(0.011)	(0.011)
Heat Anomalies × Oil Rents	-0.000	-0.000
	(0.000)	(0.000)
Potential Damages × Oil Rents	-0.013	0.002
	(0.007)	(0.012)
Heat Anomalies × Coal Rents	-0.000	-0.001
	(0.002)	(0.002)
Potential Damages × Coal Rents	1.338^{***}	1.659^{***}
	(0.121)	(0.131)
Heat Anomalies × Potential Damages × Oil Rents	-0.006^{***}	-0.006^{***}
	(0.001)	(0.001)
Heat Anomalies × Potential Damages × Coal Rents	-0.040^{***}	-0.041^{***}
	(0.004)	(0.004)
Country FE	Yes	Yes
Year FE	Yes	Yes
Countries	144	144
Years	47	47
Adjusted R^2	0.716	0.716
N	5682	5682

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$. Panel-corrected covariance matrix following Beck and Katz (1995) with errors clustered by country. CO_2 and GDP per capita scaled by 100 for exposition.

F Trimming Outliers in the Country-Level Model

Table F1: No substantive effect of trimming heat anomaly outliers on the regression of climate law stock on the interaction of heat anomalies and potential damages, 1972-2018

	Productivities:		Amenities:	
	All	5-95%	All	5-95%
Heat Anomalies × Potential Damages	0.064***	0.077***	0.059***	0.075***
	(0.006)	(0.007)	(0.006)	(0.007)
Heat Anomalies	0.007***	0.005***	0.009***	0.007***
	(0.001)	(0.001)	(0.002)	(0.002)
Potential Damages	−0.473	−0.584	1.110	1.223
	(0.802)	(0.831)	(0.718)	(0.754)
GDP per capita	0.008***	0.008***	0.008***	0.008***
	(0.000)	(0.000)	(0.000)	(0.000)
Polity2	0.035***	0.032***	0.033***	0.030***
	(0.007)	(0.007)	(0.006)	(0.006)
Coal Rents	0.099***	0.091***	0.088***	0.077***
	(0.011)	(0.011)	(0.013)	(0.013)
Oil Rents	−0.011**	−0.011**	−0.012**	−0.012**
	(0.004)	(0.004)	(0.004)	(0.004)
CO_2 per capita	−0.191	−0.618	0.297	−0.064
	(1.076)	(1.126)	(1.127)	(1.183)
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Countries	144	144	144	144
Years	47	47	47	47
Adjusted R^2	0.711	0.706	0.710	0.705
N	5682	5539	5682	5539

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$. Panel-corrected covariance matrix following Beck and Katz (1995) with errors clustered by country. CO_2 and GDP per capita scaled by 100 for exposition.

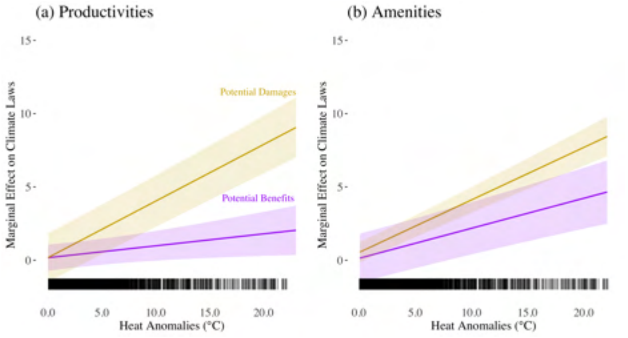


Figure F1: Marginal effects for the interaction of heat anomalies and potential climate damages after trimming outliers from below the 5th percentile and above the 95th percentile. Shaded bands denote 95 percent confidence intervals.

G Lagged Dependent Variable

Table G1: Regression of the stock of national climate mitigation laws on the interaction of heat anomalies and potential climate damages with a lagged dependent variable, 1972-2018

	Productivities	Amenities
Heat Anomalies$_{t-1}$ × Potential Damages	0.006***	0.007***
	(0.000)	(0.000)
Heat Anomalies$_{t-1}$	0.001***	0.001***
	(0.000)	(0.000)
Potential Damages	0.404	−0.360
	(0.379)	(0.375)
GDP per capita	0.000***	0.000***
	(0.000)	(0.000)
Polity2	0.004***	0.004***
	(0.000)	(0.000)
Coal Rents	0.014***	0.013***
	(0.002)	(0.002)
Oil Rents	−0.001	−0.001
	(0.001)	(0.001)
CO_2 per capita	−0.073	−0.039
	(0.063)	(0.061)
Climate Laws$_{t-1}$	1.038***	1.038***
	(0.005)	(0.004)
Country FE	Yes	Yes
Year FE	Yes	Yes
Countries	144	144
Years	46	46
Adjusted R^2	0.979	0.979
N	5607	5607

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$. Panel-corrected covariance matrix with errors clustered by country. CO_2 and GDP per capita scaled by 100 for exposition.

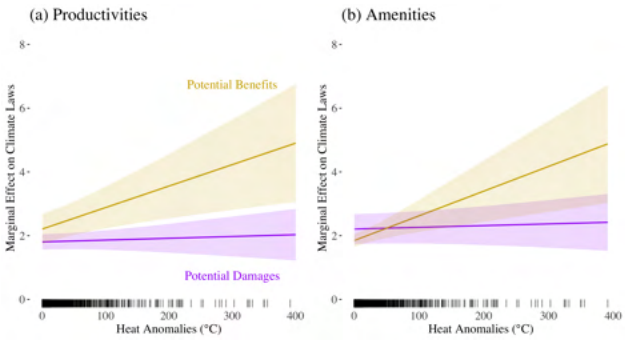


Figure G1: Marginal effects for the interaction of heat anomalies and potential climate damages in a model specification with a lagged dependent variable. Shaded bands denote 95 percent confidence intervals.

H Spatial Model Diagnostics

This appendix presents convergence diagnostics for each iteration of the spatial model using a different W. We conduct three tests of convergence: (1) a refined version of $\hat{R}$, which is the maximum of rank normalized split-$\hat{R}$ and rank normalized folded-split-$\hat{R}$, (2) the estimated bulk effective sample size (bulk-ESS) using rank normalized draws, and (3) the estimated tail effective sample size (tail-ESS) by computing the minimum of effective sample sizes for the 5 and 95 percent quantiles (Vehtari et al. 2021). We implement these tests using the `rstan` package in R and run four chains for each model. For the first test, all parameters fall beneath the 1.05 threshold, indicating that the chains have mixed well. For the latter two tests, the bulk-eSS and tail-ESS exceed 100 per Markov Chain, which suggests the estimates of posterior quantiles are reliable.

H.1 Top Emitters

Table H1: MCMC convergence diagnostics for β (amenities and top emitters W specification)

β	$\hat{R}$	bulk-ESS	tail-ESS
Intercept	1.00	37605.88	77536.69
Potential Damages	1.00	182013.94	193057.52
Heat Anomalies	1.00	140805.66	182700.70
Heat Anomalies × Potential Damages	1.00	184682.76	195696.19
GDP per capita	1.00	192462.68	195534.63
Polity2	1.00	199510.39	201155.16
Coal Rents	1.00	198962.18	196872.21
Oil Rents	1.00	197704.40	197827.32
CO2 per capita	1.00	189790.77	195999.49

Table H2: MCMC convergence diagnostics for ρ_t (amenities and top emitters W specification)

ρ_t	$\hat{R}$	bulk-ESS	tail-ESS
$t = 1995$	1.00	58913.28	109994.96
$t = 1996$	1.00	59327.75	112224.88
$t = 1997$	1.00	58130.98	107425.55
$t = 1998$	1.00	59703.07	111339.49
$t = 1999$	1.00	58700.57	116672.25
$t = 2000$	1.00	60807.06	123102.37
$t = 2001$	1.00	60304.94	119933.81
$t = 2002$	1.00	59808.29	121052.95
$t = 2003$	1.00	58305.08	115632.50
$t = 2004$	1.00	60378.41	122509.80
$t = 2005$	1.00	60252.97	121664.78
$t = 2006$	1.00	60729.33	122040.37
$t = 2007$	1.00	58913.84	119264.21
$t = 2008$	1.00	61389.78	123960.16
$t = 2009$	1.00	61060.00	120813.84
$t = 2010$	1.00	64500.12	126364.32
$t = 2011$	1.00	64259.88	126413.47
$t = 2012$	1.00	67415.59	130363.94
$t = 2013$	1.00	69267.51	128568.20
$t = 2014$	1.00	70348.44	132126.81
$t = 2015$	1.00	69591.69	128387.90
$t = 2016$	1.00	70766.52	127137.22
$t = 2017$	1.00	74919.76	134984.15
$t = 2018$	1.00	74583.59	129473.32

Table H3: MCMC convergence diagnostics for β (productivities and top emitters W specification)

β	$\hat{R}$	bulk-ESS	tail-ESS
Intercept	1.00	57028.43	109346.09
Potential Damages	1.00	58993.43	112203.39
Heat Anomalies	1.00	56348.60	109765.25
Heat Anomalies × Potential Damages	1.00	58476.19	112202.46
GDP per capita	1.00	57048.24	116302.90
Polity2	1.00	60041.83	121162.31
Coal Rents	1.00	58888.94	117641.99
Oil Rents	1.00	58882.19	118274.72
CO2 per capita	1.00	57732.44	113733.22

Table H4: MCMC convergence diagnostics for ρ_t (productivities and top emitters W specification)

ρ_t	$\hat{R}$	bulk-ESS	tail-ESS
$t = 1995$	1.00	57028.43	109346.09
$t = 1996$	1.00	58993.43	112203.39
$t = 1997$	1.00	56348.60	109765.25
$t = 1998$	1.00	58476.19	112202.46
$t = 1999$	1.00	57048.24	116302.90
$t = 2000$	1.00	60041.83	121162.31
$t = 2001$	1.00	58888.94	117641.99
$t = 2002$	1.00	58882.19	118274.72
$t = 2003$	1.00	57732.44	113733.22
$t = 2004$	1.00	60220.78	116291.87
$t = 2005$	1.00	60051.38	120461.95
$t = 2006$	1.00	61314.16	122433.29
$t = 2007$	1.00	59347.40	118017.95
$t = 2008$	1.00	58340.61	117465.81
$t = 2009$	1.00	60729.82	121406.10
$t = 2010$	1.00	63309.12	121823.09
$t = 2011$	1.00	62972.87	124651.30
$t = 2012$	1.00	65228.75	129705.61
$t = 2013$	1.00	66745.85	130695.87
$t = 2014$	1.00	68109.99	128523.11
$t = 2015$	1.00	70319.27	131320.92
$t = 2016$	1.00	71176.74	131982.98
$t = 2017$	1.00	71316.70	130007.26
$t = 2018$	1.00	74259.06	129403.06

H.2 Relative Emissions

Table H5: MCMC convergence diagnostics for β (amenities and relative emissions W specification)

β	$\hat{R}$	bulk-ESS	tail-ESS
Intercept	1.00	3231.61	6923.52
Potential Damages	1.00	197764.58	198084.37
Heat Anomalies	1.00	195448.06	198555.81
Heat Anomalies × Potential Damages	1.00	197852.43	197214.30
GDP per capita	1.00	99384.82	180441.72
Polity2	1.00	201129.39	198197.97
Coal Rents	1.00	196090.40	199678.75
Oil Rents	1.00	190987.43	194613.16
CO2 per capita	1.00	33840.89	102065.44

Table H6: MCMC convergence diagnostics for ρ_t (amenities and relative emissions W specification)

ρ_t	$\hat{R}$	bulk-ESS	tail-ESS
$t = 1995$	1.00	3170.65	6624.56
$t = 1996$	1.00	3141.52	6510.69
$t = 1997$	1.00	3142.46	6603.10
$t = 1998$	1.00	3150.28	6510.51
$t = 1999$	1.00	3159.64	6472.42
$t = 2000$	1.00	3143.04	6361.49
$t = 2001$	1.00	3171.88	6521.37
$t = 2002$	1.00	3171.48	6498.75
$t = 2003$	1.00	3161.23	6438.03
$t = 2004$	1.00	3162.56	6583.41
$t = 2005$	1.00	3158.64	6615.87
$t = 2006$	1.00	3166.46	6625.65
$t = 2007$	1.00	3157.10	6419.92
$t = 2008$	1.00	3153.67	6569.72
$t = 2009$	1.00	3151.13	6605.41
$t = 2010$	1.00	3158.26	6457.28
$t = 2011$	1.00	3162.05	6515.82
$t = 2012$	1.00	3145.59	6467.81
$t = 2013$	1.00	3152.07	6662.85
$t = 2014$	1.00	3166.57	6518.41
$t = 2015$	1.00	3161.33	6491.13
$t = 2016$	1.00	3168.58	6482.06
$t = 2017$	1.00	3166.52	6399.26
$t = 2018$	1.00	3171.08	6562.85

Table H7: MCMC convergence diagnostics for β (productivities and relative emissions W specification)

β	$\hat{R}$	bulk-ESS	tail-ESS
Intercept	1.00	3022.74	7471.54
Potential Damages	1.00	198331.76	195788.43
Heat Anomalies	1.00	143844.73	194438.01
Heat Anomalies × Potential Damages	1.00	134518.67	191333.80
GDP per capita	1.00	87849.37	177016.64
Polity2	1.00	199238.63	199803.51
Coal Rents	1.00	200511.28	198944.72
Oil Rents	1.00	192108.46	199175.27
CO2 per capita	1.00	30606.69	87383.30

Table H8: MCMC convergence diagnostics for ρ_t (productivities and relative emissions W specification)

ρ_t	$\hat{R}$	bulk-ESS	tail-ESS
$t = 1995$	1.00	2920.72	7105.09
$t = 1996$	1.00	2924.72	7031.00
$t = 1997$	1.00	2933.94	7053.51
$t = 1998$	1.00	2932.50	7038.57
$t = 1999$	1.00	2929.67	7064.13
$t = 2000$	1.00	2921.38	7002.93
$t = 2001$	1.00	2926.75	7023.44
$t = 2002$	1.00	2921.57	7090.38
$t = 2003$	1.00	2933.42	6976.42
$t = 2004$	1.00	2933.67	7132.10
$t = 2005$	1.00	2932.94	7018.04
$t = 2006$	1.00	2924.29	7147.40
$t = 2007$	1.00	2919.18	7161.61
$t = 2008$	1.00	2923.65	7140.33
$t = 2009$	1.00	2932.26	7008.77
$t = 2010$	1.00	2924.26	7138.72
$t = 2011$	1.00	2934.30	7079.96
$t = 2012$	1.00	2928.60	7028.47
$t = 2013$	1.00	2935.93	7081.82
$t = 2014$	1.00	2935.48	7222.91
$t = 2015$	1.00	2920.91	7085.32
$t = 2016$	1.00	2926.67	7091.25
$t = 2017$	1.00	2924.39	7077.48
$t = 2018$	1.00	2932.99	7084.77

H.3 Capital Distance

Table H9: MCMC convergence diagnostics for β (amenities and capital distance W specification)

β	$\hat{R}$	bulk-ESS	tail-ESS
Intercept	1.00	3992.56	9153.90
Potential Damages	1.00	137240.58	186201.83
Heat Anomalies	1.00	192679.35	195802.84
Heat Anomalies × Potential Damages	1.00	199000.37	196703.26
GDP per capita	1.00	199025.56	198084.37
Polity2	1.00	197973.38	197746.63
Coal Rents	1.00	199920.41	200136.52
Oil Rents	1.00	196052.47	195398.24
CO2 per capita	1.00	179688.40	195587.69

Table H10: MCMC convergence diagnostics for ρ_t (amenities and capital distance W specification)

ρ_t	$\hat{R}$	bulk-ESS	tail-ESS
$t = 1995$	1.00	3883.52	8678.22
$t = 1996$	1.00	3892.33	8775.97
$t = 1997$	1.00	3888.48	8746.95
$t = 1998$	1.00	3890.58	8716.59
$t = 1999$	1.00	3895.48	8761.79
$t = 2000$	1.00	3893.78	8808.88
$t = 2001$	1.00	3893.69	8677.54
$t = 2002$	1.00	3891.69	8797.94
$t = 2003$	1.00	3880.17	8706.47
$t = 2004$	1.00	3882.84	8775.11
$t = 2005$	1.00	3899.32	8803.62
$t = 2006$	1.00	3890.87	8620.00
$t = 2007$	1.00	3891.06	8639.49
$t = 2008$	1.00	3884.15	8626.04
$t = 2009$	1.00	3874.64	8736.27
$t = 2010$	1.00	3881.75	8545.23
$t = 2011$	1.00	3887.21	8683.37
$t = 2012$	1.00	3899.09	8674.54
$t = 2013$	1.00	3892.97	8701.53
$t = 2014$	1.00	3890.01	8680.94
$t = 2015$	1.00	3885.04	8809.22
$t = 2016$	1.00	3896.25	8686.99
$t = 2017$	1.00	3890.50	8625.32
$t = 2018$	1.00	3883.31	8586.46

Table H11: MCMC convergence diagnostics for β (productivities and capital distance W specification)

β	$\hat{R}$	bulk-ESS	tail-ESS
Intercept	1.00	3568.52	9915.24
Potential Damages	1.00	192225.58	197737.50
Heat Anomalies	1.00	199096.83	196564.36
Heat Anomalies × Potential Damages	1.00	200121.96	197434.98
GDP per capita	1.00	195200.00	199307.08
Polity2	1.00	200707.89	199700.59
Coal Rents	1.00	199183.92	199615.43
Oil Rents	1.00	198768.48	199547.25
CO2 per capita	1.00	152211.86	197612.90

Table H12: MCMC convergence diagnostics for ρ_t (productivities and capital distance W specification)

ρ_t	$\hat{R}$	bulk-ESS	tail-ESS
$t = 1995$	1.00	3474.87	9405.65
$t = 1996$	1.00	3495.06	9335.92
$t = 1997$	1.00	3476.11	9137.08
$t = 1998$	1.00	3467.91	9176.86
$t = 1999$	1.00	3474.61	9208.05
$t = 2000$	1.00	3480.72	9269.11
$t = 2001$	1.00	3463.25	9211.85
$t = 2002$	1.00	3454.05	9053.63
$t = 2003$	1.00	3476.61	9105.17
$t = 2004$	1.00	3480.49	9181.70
$t = 2005$	1.00	3480.12	9248.13
$t = 2006$	1.00	3482.30	9187.26
$t = 2007$	1.00	3478.87	9249.77
$t = 2008$	1.00	3501.39	9149.39
$t = 2009$	1.00	3475.17	9124.63
$t = 2010$	1.00	3470.56	9240.58
$t = 2011$	1.00	3498.84	9121.27
$t = 2012$	1.00	3472.71	9148.80
$t = 2013$	1.00	3490.02	9153.65
$t = 2014$	1.00	3468.83	9058.29
$t = 2015$	1.00	3488.48	9111.57
$t = 2016$	1.00	3481.64	9066.65
$t = 2017$	1.00	3481.15	9105.84
$t = 2018$	1.00	3510.74	9097.16

I Fuzzy Matching Diagnostics

The majority of municipalities reporting climate actions to CDP match with the sampling frame of cities from the `maps` package in `R`. Table I1 reports the proportion of cities in each United Nations sub-region that reported climate actions but did not obtain a match. The largest share of unmatched cities is in Latin America and the Caribbean, which should bias against our results because this region is especially exposed to climate damages.

Table I1: United Nations sub-regions for cities that reported climate actions but obtain no matches with sampling frame of cities

Region	Proportion
Australia and New Zealand	0.030
Eastern Asia	0.079
Latin America and the Caribbean	0.499
Northern America	0.110
Northern Europe	0.079
South-eastern Asia	0.058
Southern Asia	0.022
Southern Europe	0.027
Sub-Saharan Africa	0.052
Western Asia	0.027
Western Europe	0.016

J Mechanism Regression Tables

Table J1: Weak prior regressions of individual concern about climate change on the interaction of heat anomalies and potential climate damage

	Productivities		Amenities	
	Logit	OLS	Logit	OLS
Heat Anomalies$_{t-1}$ × Potential Damages	0.004^{**}	0.001^{*}	0.012^{***}	0.003^{***}
	(0.001)	(0.000)	(0.001)	(0.000)
Heat Anomalies$_{t-1}$	0.003^{***}	0.001^{**}	0.003^{***}	0.001^{**}
	(0.001)	(0.000)	(0.001)	(0.000)
Potential Damages	0.220^{***}	0.055^{***}	-0.356^{***}	-0.082^{***}
	(0.046)	(0.012)	(0.049)	(0.012)
Age	0.000	0.000	−0.001	−0.000
	(0.001)	(0.000)	(0.001)	(0.000)
Sex	0.044	0.012	0.037	0.012
	(0.030)	(0.008)	(0.030)	(0.008)
Income: First Tercile	0.058	0.007	0.055	0.006
	(0.045)	(0.011)	(0.045)	(0.011)
Income: Third Tercile	-0.100^{*}	-0.023^{*}	−0.069	−0.016
	(0.039)	(0.010)	(0.039)	(0.010)
Ideology: Left	0.207^{***}	0.046^{***}	0.224^{***}	0.050^{***}
	(0.042)	(0.010)	(0.042)	(0.010)
Ideology: Right	-0.267^{***}	-0.065^{***}	-0.255^{***}	-0.062^{***}
	(0.035)	(0.009)	(0.035)	(0.009)
College	0.323^{***}	0.072^{***}	0.262^{***}	0.058^{***}
	(0.033)	(0.008)	(0.033)	(0.008)
Employed	−0.014	−0.007	−0.001	−0.004
	(0.031)	(0.008)	(0.031)	(0.008)
Coal Rents	-0.289^{***}	-0.070^{***}	-0.350^{***}	-0.085^{***}
	(0.032)	(0.009)	(0.031)	(0.009)
Oil Rents	0.020^{***}	0.005^{***}	0.041^{***}	0.010^{***}
	(0.004)	(0.001)	(0.005)	(0.001)
GDP per capita	−0.000	−0.000	-0.001^{***}	-0.000^{***}
	(0.000)	(0.000)	(0.000)	(0.000)
CO$_2$ per capita	−0.412	0.005	-1.974^{***}	-0.356^{**}
	(0.477)	(0.121)	(0.483)	(0.124)
N	20110	20110	20110	20110
Countries	38	38	38	38
Log Likelihood	−13305.754		−13299.651	
Adjusted R^2		0.024		0.025

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$. Errors clustered by country and adjusted for heteroskedasticity with the HC2 variance estimator. GDP per capita scaled by 10,000 for exposition.

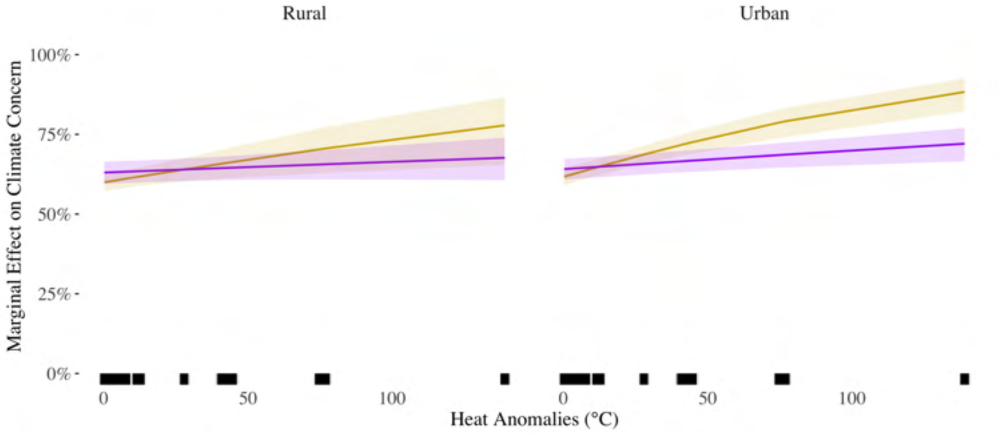
Table J2: Strong priors regressions of individual concern about climate change on the interaction of heat anomalies and potential climate damages

	Productivities:		Amenities:	
	Logit	OLS	Logit	OLS
Heat Anomalies$_{t-1}$ × Potential Damages	-0.001	-0.000	0.003^{***}	0.001^{***}
	(0.001)	(0.000)	(0.001)	(0.000)
Heat Anomalies$_{t-1}$	0.001^{***}	0.000^{***}	0.000^{**}	0.000^{**}
	(0.000)	(0.000)	(0.000)	(0.000)
Potential Damages	0.106^{***}	0.026^{***}	0.168^{***}	0.042^{***}
	(0.019)	(0.005)	(0.018)	(0.004)
Age	0.003^{***}	0.001^{***}	0.003^{***}	0.001^{***}
	(0.000)	(0.000)	(0.000)	(0.000)
Gender	-0.052^{***}	-0.013^{***}	-0.051^{***}	-0.013^{***}
	(0.014)	(0.003)	(0.014)	(0.003)
Education	0.426^{***}	0.104^{***}	0.442^{***}	0.107^{***}
	(0.020)	(0.005)	(0.019)	(0.005)
Income: 80th Percentile	0.074^{**}	0.018^{**}	0.074^{**}	0.018^{**}
	(0.023)	(0.006)	(0.023)	(0.006)
Income: 60th Percentile	0.096^{***}	0.023^{***}	0.096^{***}	0.024^{***}
	(0.022)	(0.005)	(0.022)	(0.005)
Income: 40th Percentile	0.121^{***}	0.030^{***}	0.121^{***}	0.030^{***}
	(0.022)	(0.005)	(0.022)	(0.005)
Income: 20th Percentile	0.178^{***}	0.044^{***}	0.178^{***}	0.044^{***}
	(0.022)	(0.005)	(0.022)	(0.005)
Urban	0.183^{***}	0.045^{***}	0.171^{***}	0.042^{***}
	(0.014)	(0.004)	(0.014)	(0.004)
Coal Rents	-0.069^{***}	-0.016^{***}	-0.075^{***}	-0.017^{***}
	(0.010)	(0.002)	(0.010)	(0.002)
Oil Rents	-0.015^{***}	-0.004^{***}	-0.015^{***}	-0.004^{***}
	(0.001)	(0.000)	(0.001)	(0.000)
GDP per capita	0.001^{***}	0.000^{***}	0.001^{***}	0.000^{***}
	(0.000)	(0.000)	(0.000)	(0.000)
CO_2 per capita	-4.206^{***}	-1.009^{***}	-4.164^{***}	-1.000^{***}
	(0.244)	(0.057)	(0.240)	(0.056)
Countries	142	142	142	142
N	157461	157461	157461	157461
Adjusted R^2		0.019		0.021
Log Likelihood	-85731		-85607	

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$. Errors clustered by country and adjusted for heteroskedasticity with the HC2 variance estimator. CO_2 per capita data from 2018 due to availability.

K City Interaction Effects

(a) Productivities



(b) Amenities

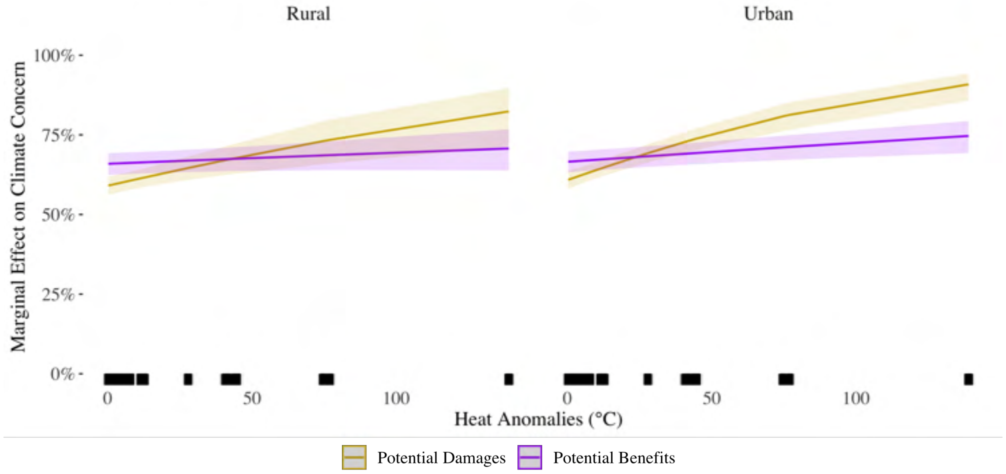
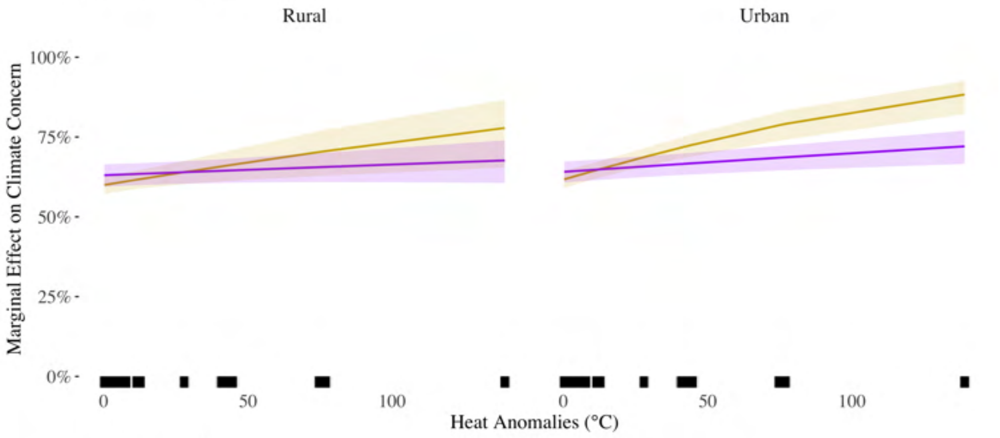


Figure K1: Updating with weak priors – marginal effects by urban versus rural for the interaction of heat anomalies and potential damages on individual concern about climate change. Data from WVS. $N = 14371$ respondents in 29 countries. Shaded bands denote 95 percent confidence intervals.

(a) Productivities



(b) Amenities

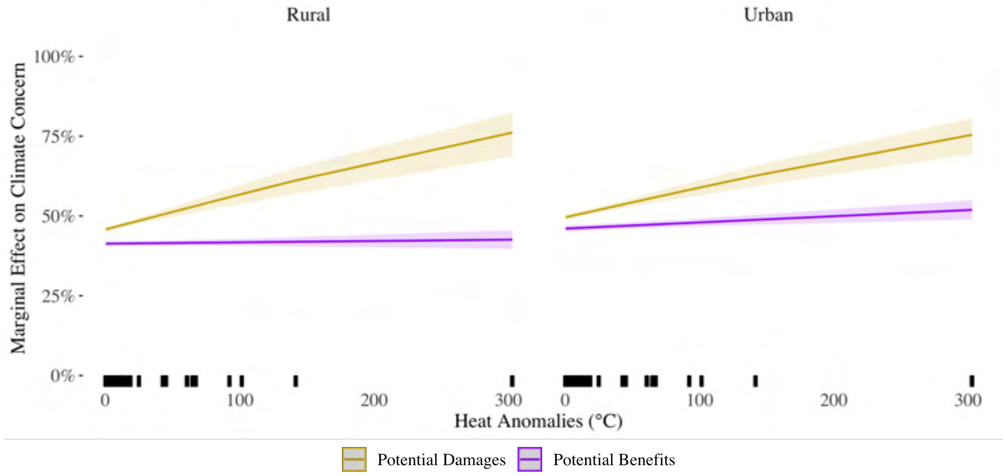


Figure K2: Updating with strong priors – marginal effects by urban versus rural for the interaction of heat anomalies and potential damages on individual concern about climate change. Shaded bands denote 95 percent confidence intervals.

Table K1: Weak prior regressions of individual concern about climate change on the interaction of urban, heat anomalies, and potential climate damage

	Productivities		Amenities	
	Logit	OLS	Logit	OLS
Heat Anomalies$_{t-1}$	0.001	0.000	0.002	0.000
	(0.001)	(0.000)	(0.001)	(0.000)
Potential Damages	−0.129	−0.030	-0.294^{***}	-0.069^{***}
	(0.073)	(0.017)	(0.074)	(0.018)
Urban	0.046	0.011	0.028	0.006
	(0.072)	(0.017)	(0.069)	(0.016)
Sex	0.019	0.005	0.017	0.004
	(0.035)	(0.008)	(0.035)	(0.008)
Age	0.001	0.000	0.001	0.000
	(0.001)	(0.000)	(0.001)	(0.000)
Income: First Tercile	0.077	0.018	0.072	0.017
	(0.054)	(0.013)	(0.054)	(0.013)
Income: Third Tercile	−0.074	−0.017	−0.065	−0.015
	(0.046)	(0.011)	(0.046)	(0.011)
Ideology: Left	0.225^{***}	0.050^{***}	0.228^{***}	0.051^{***}
	(0.050)	(0.011)	(0.050)	(0.011)
Ideology: Right	-0.285^{***}	-0.068^{***}	-0.281^{***}	-0.067^{***}
	(0.041)	(0.010)	(0.041)	(0.010)
College	0.321^{***}	0.076^{***}	0.306^{***}	0.073^{***}
	(0.039)	(0.009)	(0.039)	(0.009)
Employed	0.014	0.004	0.016	0.004
	(0.037)	(0.009)	(0.037)	(0.009)
Coal Rents	-0.433^{***}	-0.101^{***}	-0.444^{***}	-0.104^{***}
	(0.053)	(0.013)	(0.053)	(0.013)
Oil Rents	0.044^{***}	0.010^{***}	0.051^{***}	0.012^{***}
	(0.006)	(0.001)	(0.006)	(0.001)
GDP per capita	-0.000^{**}	-0.000^{**}	-0.001^{***}	-0.000^{***}
	(0.000)	(0.000)	(0.000)	(0.000)
CO_2 per capita	−0.546	−0.124	−0.909	−0.206
	(0.541)	(0.125)	(0.546)	(0.126)
Heat Anomalies$_{t-1}$ × Potential Damages	0.005^{*}	0.001	0.007^{**}	0.002^{**}
	(0.002)	(0.001)	(0.002)	(0.001)
Heat Anomalies$_{t-1}$ × Urban	0.001	0.000	0.001	0.000
	(0.001)	(0.000)	(0.001)	(0.000)
Potential Damages × Urban	0.027	0.006	0.047	0.011
	(0.088)	(0.021)	(0.087)	(0.021)
Heat Anomalies$_{t-1}$ × Potential Damages × Urban	0.004	0.001	0.004	0.001
	(0.003)	(0.001)	(0.003)	(0.001)
N	14371	14371	14371	14371
Countries	29	29	29	29
Log Likelihood	−9535.385		−9527.369	
Adjusted R^2		0.026		0.027

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$. Errors clustered by country and adjusted for heteroskedasticity with the HC2 variance estimator. GDP per capita scaled by 10,000 for exposition.

Table K2: strong prior regressions of individual concern about climate change on the interaction of urban, heat anomalies, and potential climate damage

	Productivities		Amenities	
	Logit	OLS	Logit	OLS
Heat Anomalies$_{t-1}$	0.001**	0.000**	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Potential Damages	0.109***	0.027***	0.183***	0.046***
	(0.023)	(0.005)	(0.022)	(0.004)
Urban	0.145***	0.036***	0.193***	0.048***
	(0.028)	(0.006)	(0.024)	(0.005)
Age	0.003***	0.001***	0.003***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Gender	−0.052***	−0.012***	−0.051***	−0.012***
	(0.014)	(0.003)	(0.014)	(0.003)
Education	0.426***	0.096***	0.440***	0.099***
	(0.020)	(0.004)	(0.019)	(0.004)
Income: 80th Percentile	0.074**	0.026***	0.075***	0.027***
	(0.023)	(0.005)	(0.023)	(0.005)
Income: 60th Percentile	0.096***	0.031***	0.096***	0.031***
	(0.022)	(0.005)	(0.022)	(0.005)
Income: 40th Percentile	0.120***	0.044***	0.121***	0.044***
	(0.022)	(0.005)	(0.022)	(0.005)
Income: 20th Percentile	0.178***	0.060***	0.178***	0.060***
	(0.022)	(0.004)	(0.022)	(0.004)
Coal Rent	−0.066***	−0.017***	−0.076***	−0.019***
	(0.010)	(0.002)	(0.010)	(0.002)
Oil Rent	−0.015***	−0.004***	−0.015***	−0.004***
	(0.001)	(0.000)	(0.001)	(0.000)
GDP per capita	0.001***	0.000***	0.001***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
CO_2 per capita	−4.091***	−1.059***	−4.135***	−1.070***
	(0.245)	(0.047)	(0.240)	(0.046)
Heat Anomalies$_{t-1}$ × Potential Damages	−0.003***	−0.001***	0.004***	0.001***
	(0.001)	(0.000)	(0.001)	(0.000)
Heat Anomalies$_{t-1}$ × Urban	0.000	0.000	0.001	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Heat Anomalies$_{t-1}$ × Urban			−0.040	−0.010
			(0.031)	(0.006)
Potential Damages × Urban	0.007	0.001		
	(0.033)	(0.007)		
Heat Anomalies$_{t-1}$ × Potential Damages × Urban	0.005***	0.001***	−0.001	−0.000
	(0.001)	(0.000)	(0.001)	(0.000)
N	128750	128750	128750	128750
Countries	119	119	119	119
Log Likelihood	−85707.934		−85602.569	
Adjusted R^2		0.022		0.023

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$. Errors clustered by country and adjusted for heteroskedasticity with the HC2 variance estimator. GDP per capita scaled by 10,000 for exposition.

L Accounting for Additional Climate Hazards

To address other dimensions of climate damage, we run a model specification that accounts for the economic effects of sea level rise (SLR). We employ Desmet et al.'s (2021) dynamic economic assessment model. This model is built from the same framework as CR, which enhances comparability. The results show that coastal flooding due to SLR also has potential damages and benefits.

We incorporate an indicator into our main empirical specification for if a country experiences potential damages from SLR. Table L1 reports the results of re-estimating (1) with the new control. There is no appreciable change in the results. The indicator for coastal flooding damage is positive and significant ($p < 0.01$) as expected. Areas facing concentrated damage from SLR have a strong motivation to mitigate emissions.

Table L1: Regression of the stock of national climate mitigation laws on the interaction of heat anomalies and potential climate damages when accounting for damages from sea level rise, 1972-2018

	Productivities	Amenities
Heat Anomalies$_{t-1}$ × Potential Damages	0.073^{***}	0.071^{***}
	(0.007)	(0.006)
Heat Anomalies$_{t-1}$	0.007^{***}	0.009^{***}
	(0.001)	(0.001)
Potential Damages	-0.460	1.100
	(0.772)	(0.687)
GDP per capita	0.008^{***}	0.008^{***}
	(0.000)	(0.000)
Polity2	0.032^{***}	0.030^{***}
	(0.007)	(0.006)
Coal Rents	0.095^{***}	0.084^{***}
	(0.012)	(0.014)
Oil Rents	-0.011^{*}	-0.012^{*}
	(0.005)	(0.005)
CO_2 per capita	-0.515	0.010
	(1.129)	(1.183)
Coastal Flooding Damage	1.925^{**}	0.815^{***}
	(0.693)	(0.196)
Country FE	Yes	Yes
Year FE	Yes	Yes
Countries	144	144
Years	46	46
Adjusted R^2	0.711	0.711
N	5607	5607

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$. Panel-corrected covariance matrix following Beck and Katz (1995) with errors clustered by country. CO_2 and GDP per capita scaled by 100 for exposition.