

Public Opinion Regarding Climate Change: Measuring Public Concern and Polarization Across Countries and Over Time

Project Description

Effectively addressing climate change necessitates understanding the interplay between policy, politics, and public opinion. Understanding how public opinion on climate change affects policy, especially across partisan lines, urban-rural divides, and gender differences, is crucial, as polarization challenges the implementation and sustainability of climate reforms. However, existing theories often prioritize collective action problems (Barrett 2003; Keohane and Victor 2016; Nordhaus 2015; Ostrom 1990) and distributive politics (Aklin and Mildenberger 2020; Colgan, Green, and Hale 2021), overlooking the critical role of public attitudes, despite their influence on government actions in democracies (Burstein 2003; Dahl 1971) and in authoritarian countries (Alkon and Wang 2018). We analyzed 70 highly-cited articles on public opinion toward climate change, identified from the top 100 Web of Science and Google Scholar results (duplicates removed), spanning 1998 to 2022. Many of these studies relied on case-study or small-n designs, with nearly half examining four or fewer countries and years, and over a third focusing on a single year in a single country. This highlights the significant absence of comprehensive, longitudinal, and cross-national studies in the field, making it imperative to fill this critical research gap.

The reason for this oversight is the lack of systematic cross-country public opinion data on climate change. Comparative public opinion data are sparse and fragmented, with many countries and years lacking data, and existing data often being incomparable due to differences in items and interpretations. These challenges are particularly severe for climate change opinion. Unlike established concepts such as democratic support, trust, and gender egalitarianism, climate-related questions have only been surveyed sporadically since the 1990s, mainly in developing countries. Actually, even for OECD countries, due to the absence of comparative data, Schaffer, Oehl, and Bernauer (2022) had to use media coverage of climate issues as a proxy for public concerns over 15 years. Our preliminary data collection from 93 different survey datasets from 1992 to 2022 highlights this sparsity, with only 3,830 country-year-item observations representing 37% of the total possible data.

To address these challenges, we will rely on the Dynamic Comparative Public Opinion model (DCPO) (Solt 2020) for latent variable estimation on climate change. The DCPO model has been widely used in cross-national opinion estimation (Hu and Solt n.d.; Woo et al. 2024; Woo, Goldberg, and Solt 2023) among other latent variable models (Caughey, O'Grady, and Warshaw 2019; e.g., Claassen 2019; Kołczyńska et al. 2024; McGann, Dellepiane-Avellaneda, and Bartle 2019). We plan to expand the survey source data both temporally and geographically by including more country-specific surveys. We will also improve the latent-variable estimation model by incorporating new

techniques to ensure DCPO's estimates are comparable. This includes setting stronger priors for change over time and in data-poor countries, and nesting similar items in hierarchical models to address item-comparability issues. Additionally, we will develop and test various methods for generating polarization estimates.

Our project aims to build crucial research infrastructure for cross-national work on climate change, polarization, and broader public opinion. We will disseminate the resulting estimates to researchers, educators, students, and policymakers worldwide through conference presentations, a symposium, scholarly publications, and a web interface. This work will enhance our understanding of the relationship between public opinion and climate policies, ultimately contributing to more informed and effective climate action.

1 Background

There is a very large existing literature that explains public opinion on climate change (e.g., citizen knowledge, attention, concern for climate change as well as policy preferences) in especially developed economies. For instance, many have shown that climate change triggered extreme weather events (e.g., droughts, wildfires, and hurricanes) increase public climate change concerns and preferences for mitigation policies. This scholarly enthusiasm to explain climate public opinion is probably underpinned by an underlying assumption that one needs public opinion support to produce climate policies to combat climate change; in other words, public opinion matters in the realm of climate policies. But does it? More specifically, would public opinion on climate change affect national climate change policy outputs? Surprisingly, the literature is silent when it comes to this obvious and yet extremely important question. The reason for this is simple and yet it presents a great challenge for the research community: there is no systematic data on cross-country public opinion regarding climate change.

With the looming threat of climate change, it is vital for us to understand climate policies and politics. Existing theories on the subject largely focus on collective action and distributive politics, ignoring the potential impact of public sentiment. Collective action theory treats carbon mitigation as a global public good, with countries free-riding on one another the core challenge (Barrett 2003; Keohane and Victor 2016; Nordhaus 2015; Ostrom 1990). However, it fails to explain why some countries are more proactive/less free-riding in mitigation than others. Distributive politics, on the other hand, views climate policy as a battleground for interest groups, some of which would lose while others might gain from climate mitigation (Aklin and Mildenberger 2020; Colgan, Green, and Hale 2021). Owners of so called "climate-forcing" assets (those generating large amounts of carbon emissions) stand to lose with stringent mitigation policies and have been a large barrier to effective climate policy. One key question that remains to be answered is whether pro-mitigation public preferences can outweigh these anti-mitigation forces.

Traditional wisdom suggests that public opinion influences public policy through government responsiveness (Dahl 1971), a dynamic observed even in authoritarian countries (Alkon and Wang 2018; Meng, Pan, and Yang 2017; Miller 2015). In Burstein (2003)'s influential review on public opinion and policy, it was found that while public opinion often strongly influences policy, most studies focus on the US and a few West European countries, with minimal attention to

developing countries. According to the Web of Science, since 1990, there have been 1,829 articles on environment/climate change and public opinion, with 306 focused on the United States, 128 on China, 114 on the EU, 38 on Africa, and 15 on Latin America. Narrowing the scope to cross-national research reduces the count to 28. Among these, most studies have examined the determinants of environment/climate attitude and the determinants climate policies independently (Fankhauser, Gennaioli, and Collins 2014; Hao and Shao 2021; Papież, Śmiech, and Frodyma 2018; e.g., Stenner and Nwokora 2015); few consider the role of public opinion in affecting environmental and climate policy outputs: here only proxy measures of climate public opinion (e.g., using environmental rather than climate attitudes as well as media coverage of climate issues) are used (Anderson, Böhmelt, and Ward 2017; Bakaki, Böhmelt, and Ward 2020; Schaffer, Oehl, and Bernauer 2022).

Again, cross-national analyses overlook the role of public opinion due to data limitations. Even for broader attitudes towards environmental issues, comprehensive multi-decade, cross-national surveys are lacking (Von Stein 2022). Anderson, Böhmelt, and Ward (2017) found a positive relationship between public environmental attitudes (using Eurobarometer data) and renewable energy policy outputs in Europe from 1974 to 2015. Similarly, Bakaki, Böhmelt, and Ward (2020) identified a triangular relationship between citizens' environmental concerns, media attention, and renewable policy output in six European democracies from 1983 to 2012. The limited spatial coverage is primarily due to the lack of data. The situation is even more severe for climate change attitudes. Due to the absence of comparative climate opinion data, Schaffer, Oehl, and Bernauer (2022) used media coverage of climate issues as a proxy for public concerns in studying climate change mitigation in six OECD countries over a period of 1995-2010, even though this measure has low validity given its low correlation ($r = 0.27$) with climate public opinion data (Oehl, Schaffer, and Bernauer 2017) and the authors acknowledge that “public opinion surveys arguably provide the most direct measure of public demand.” (see, p.~137, Schaffer, Oehl, and Bernauer 2022).

In addition to the average level of public climate concern, how such concerns are distributed within a society, especially along with existing salient social cleavages – partisan lines, urban-rural divide, and gender differences, to name but a few – is equally if not more important for climate policies. Polarization in climate concerns captures the intuition that significant differences in views and preferences towards climate issues exist and likely increase between different groups of people in a society. It is an important concept with profound policy implications. Addressing the climate challenge requires a transformation of our societies and this scale of change depend upon far-reaching reforms from governments that many believe are only possible when there is a widespread social and political support for such a transition. Increasing political polarization of climate policy-relevant attitudes would inhibit such climate reforms. It signifies popular disagreement on issues surrounding climate policies and provide fertile grounds for political mobilization that often blocks necessary reforms. Therefore, many believe that political polarization of public attitudes relevant to climate change presents a challenge for not only the implementation but also the durability of climate reforms.

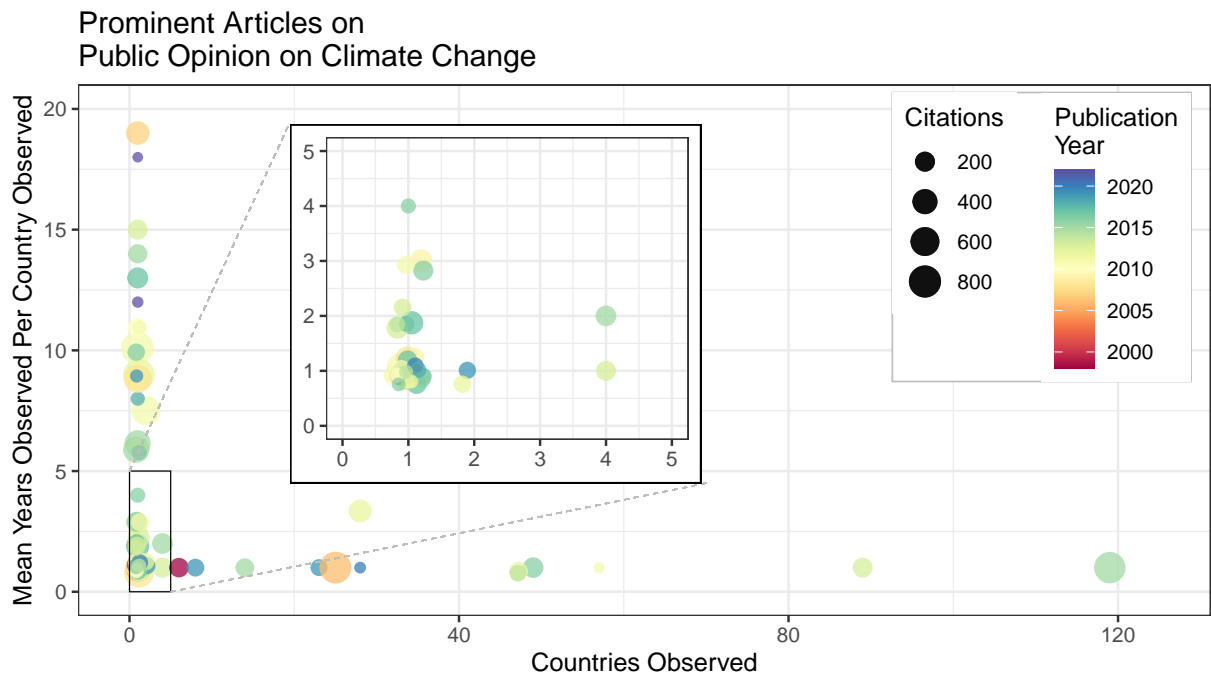
Public opinion on climate change has become increasingly complex during times of polarization. In the U.S., climate change is a deeply divisive and politicized issue, with political ideology significantly influencing attitudes towards climate and environmental policies (Czarnek, Kossowska, and Szwed 2021; Jasny, Waggle, and Fisher 2015; McCright and Dunlap 2011). Liberals generally show greater support for climate change policies than conservatives (Boudet et al. 2020; Egan and

Mullin 2017; Hazlett and Mildenberger 2020; McCright et al. 2016; Merkley and Stecula 2018).

In other countries, factors such as gender, race, education, income, and socioeconomic status also influence public climate attitudes, as shown in various cross-national studies (Hornsey et al. 2016; Lee et al. 2015; Lewis, Palm, and Feng 2019; Pearson et al. 2017). For instance, women in wealthier countries in the Americas and Europe are more likely to be concerned about climate change than men, possibly because men perceive higher costs in climate mitigation policies since they benefit more from the current hierarchical political and social system (Bush and Clayton 2023).

However, despite the evident polarization in climate change opinion, there is a lack of studies measuring the polarization in climate change attitudes and its effect on policy outputs and outcomes.

It is well documented that comparative public opinion studies have been hampered by the lack of comprehensive data, not to mention public polarization data. The scarcity of comparative data at the aggregate level is due to data sparseness and fragmentation, with many countries and years lacking data, and existing data often being incomparable due to differences in items and interpretations. However, an emerging group of scholars has been dedicated to developing models to measure comparative public opinion across countries over time (Caughey, O’Grady, and Warshaw 2019; Claassen 2019; Kołczyńska et al. 2024; McGann, Dellepiane-Avellaneda, and Bartle 2019; Solt 2020). Among these, the Dynamic Comparative Public Opinion model (DCPO) (Solt 2020) has been widely used to measure comparative public opinion and has successfully created comparative data for gender egalitarianism (Woo, Goldberg, and Solt 2023), macrointerest (Hu and Solt n.d.), and tolerance of homosexuality (Woo et al. 2024).



Note: Citation counts as reported by the Web of Science on June 15, 2024.

Figure 1: Countries and Mean Years Observed in Prominent Research

Regarding climate change public opinion, we first explored the country-year coverage of climate-

change questions in existing surveys and the literature. Figure 1 shows how the available data have influenced scholarship on the topic. Using the Web of Science and Google Scholar, we assembled a sample of prominent published articles on public opinion toward climate change.¹ These articles had publication dates as early as 1998 and as late as 2022 (median: 2013) and were cited in the Web of Science from 5 to 847 times (median: 150.5). We then examined these articles to find the number of countries and years investigated in each. As the zoomed portion of the plot pocc-plot emphasizes, many of these articles might be described as using case-study or small- n research designs. Just over a third consider only a single year in a single country; together with works that study four and fewer countries and years (inset) they comprise nearly half of this sample.

In addition, climate change data presents distinctive challenges. First, the data are particularly fragmented among many different survey questions due to the rapid changes in the salience of the climate change topic and specific subtopics, from climate knowledge to policy preference. Second, an unusually large number of countries are data-poor. Moreover, regarding climate-change opinion, researchers are particularly interested in *polarization* in attitudes, but existing latent-variable solutions have paid little attention to this.

The lack of extensive cross-sectional time series data on public opinion and polarization regarding climate change significantly impedes research in the fields of opinion and climate policy. Our project aims to expand both the geographic and temporal dimensions and contribute to the literature on public opinion, polarization, and policy outcomes related to climate change policies.

2 The Proposed Research

The proposed research comprises four principal activities: (1) expanding the survey source data, (2) generating estimates for public opinion on climate change, (3) developing and testing a range of methods for generating polarization estimates, and (4) disseminating the resulting estimates to researchers, educators, students, and policymakers worldwide through conference presentations, scholarly publications, open-source software, and a web interface.

We will rely on the Dynamic Comparative Public Opinion model (DCPO) (Solt 2020) to measure public opinion since it has been widely used in measuring comparative public opinion and successfully generated comparative datasets in gender egalitarianism (Woo, Goldberg, and Solt 2023), macrointerest (Hu and Solt n.d.), and tolerance of homosexuality (Woo et al. 2024).

The DCPO model is a population-level two-parameter ordinal logistic item response theory (IRT) model. It interprets an individual's response to a certain question as a function of the mean latent public attitude of a population at a country-year level, the difficulty of giving a certain answer to

¹Web of Science topic searches return articles in which the search terms appear in the title or abstract. We executed the following search: TS=("public opinion" AND ("climate change" OR "global warming" OR "greenhouse effect")). The fifty most-cited empirical research articles returned were retained. Google Scholar, according to its about page, "aims to rank documents the way researchers do, weighing the full text of each document, where it was published, who it was written by, as well as how often and how recently it has been cited in other scholarly literature." We searched "public opinion" "climate change" and identified the first fifty articles returned. Then we added the Web of Science records for the Google Scholar results (to ensure consistency of citation counts) to our original Web of Science sample and dropped all duplicates, yielding a total of 70 different articles.

the question, and the degree to which the question measures the latent attitude. By incorporating country-specific characteristics that capture systematic differences in responses due to cultural factors or distinct interpretations, DCPO ensures comparability of measured latent attitudes between countries. Furthermore, through local random walk, DCPO smooths the missing measures based on available data from previous years.

Expanding the survey source data. To measure public opinion toward climate change, we have collected raw data from 93 different survey datasets and identified 43 survey items that were asked in at least five country-years in countries surveyed more than three times. These items have been asked in 87 different countries at least three times over the past 30 years, from 1992 to 2022. Despite our extensive collection efforts, the current source data covers 978 country-years and includes a total of 3,830 country-year-item observations, which represents 37% of a complete set of total country-year data.

This initial effort demonstrates the potential for building a comprehensive cross-national time-series dataset on climate opinion while also highlighting the challenges in measuring comparative public climate data. Our primary focus has been on well-known and publicly-accessible cross-national surveys, including the World Values Survey, Eurobarometer, European Social Survey, International Social Survey Programme, and Regional Barometer surveys, supplemented by a few country-specific surveys.

These established worldwide surveys have advantages in standardized questions and thorough documentation, but they also have limitations in geographic and temporal coverage. For instance, the World Values Survey and Regional Barometer Survey are typically conducted every four years, while the International Social Survey Programme's topic modules are conducted approximately every five to ten years. Relying solely on these publicly accessible cross-national surveys is insufficient.

There are also public but non-accessible survey projects. For example, Gallup has included climate change questions in their surveys since 2005, providing a valuable dataset for climate change. However, this data is only available to subscribers, making it difficult to access without project funding.

Expanding the dataset to include more country-specific surveys will enhance the geographical and temporal scope of the raw data. However, this expansion will require a significant commitment of time and resources due to language barriers and difficulties in accessing data. For instance, the Finnish Social Science Data Archive has surveys with climate or energy-relevant questions dating back to 2000. Most of these surveys are in Finnish, requiring research assistance to identify relevant questions and clean the raw data. Similarly, other non-English surveys necessitate research assistance, further emphasizing the need for funding to hire skilled research assistants.

In addition to expanding survey datasets, we will expand survey items to include both climate-related items and environment-related items. Both general questions about environmental concern and protection and specific questions about environmental policy preferences will be identified and incorporated into our source data. Additionally, the severe sparsity of identical questions across different survey projects necessitates further development of the DCPO model to address these inconsistencies. We will also identify demographic and political information of respondents in survey datasets, including but not limited to gender, religion, residence location, and ideology.

These demographics will allow us to estimate public opinion between subpopulations, which we will illustrate in the polarization estimates section.

Generating estimates for public opinion on climate change. To estimate public climate change attitudes across countries and over time, we employ the Dynamic Comparative Public Opinion (DCPO) model as presented in Solt (2020). Other models usually require a high quality data, either dense survey data or ancillary data on population characteristics Kołczyńska et al. (2024). The latest development in this stream is Berwick and Caughey (2024)'s dynamic multidimensional group-level IRT model. By using an exploratory approach, their method can measure multidimensional opinions by poststratifying subpopulation opinion estimates. The exploratory method can help understand complex opinion structures when scholars care about dimensions. However, the practicality of poststratifying subpopulation estimates in scenarios involving numerous countries and extended time periods is questionable and may present challenges. Compared to these models, DCPO is specifically designed to address issues of incomparability and sparsity in comparative opinion data over time with fewer data requirements.

DCPO handles incomparability with two key parameters: *difficulty* and *dispersion*. Difficulty indicates the level of climate change attitude represented by a given response. For instance, answering “very concerned” to the question “To what extent are you concerned about climate change?” shows more supportive attitude than answering “somewhat concerned,” “little concerned,” or “not at all.” Similarly, giving “very high priority” to the question “How high a priority do you think the government SHOULD place on addressing climate change?” indicates more support than merely expressing concern.

Dispersion measures the degree to which a question can capture the latent attitude towards climate change. A smaller dispersion suggests that changes in question responses can better reflect changes in supportive attitudes. For example, compared to the question about the degree of agreement with “Climate change is caused by human behavior,” the response to “Would you be willing to give part of your income or pay more taxes if you were sure that the extra money was used to handle climate change?” can better map onto the change in climate attitude.

To address the sparsity of source data, which includes inconsistencies in the time series of each country due to unobserved country-years or limited observed items, DCPO uses local-level dynamic linear models. These models estimate public opinion by taking the previous year's estimate and adding a random shock. This approach smooths the estimates over time and allows for estimation even in years with little or no survey data, albeit at the expense of greater measurement uncertainty[[^]Scholars have developed and tested approaches to incorporate measurement uncertainty (Tai, Hu, and Solt 2022)].

To facilitate data collection, measurement, and broader open data science, DCPO has developed two open-source R packages: DCPO and DCPOtools. DCPOtools, designed by Solt, Hu, and Tai (2019), automates the process of collecting the necessary survey items from datasets and performs data wrangling computationally. This increases the efficiency and transparency of data processing, avoids data entry errors, and facilitates reproducibility. DCPO is the package written in Stan for running DCPO models and estimating latent public opinion from cross-national survey data collected through DCPOtools. Together, these tools enable scholars to translate survey data into estimates of public opinion.

Developing and testing a range of methods for generating polarization estimates. To generate polarization estimates, we will revise and expand the DCPO model and relevant packages to identify and aggregate subpopulation opinions. Although existing studies usually focus on partisan polarization, polarization exists across different subgroups. We will estimate polarization between ideological left and ideological right, female and male, urban and rural, and religious and secular.

To this end, we will first revise DCPOtools to automatically collect and process ancillary data on population characteristics based on our expanded source data. Secondly, we will develop the DCPO model and package to estimate public opinion within subpopulation groups and then the cleavage of opinion between subpopulation groups.

Disseminating the resulting estimates.

We will achieve broad dissemination through conference presentations, scholarly publications, software, dataverse, and a user-friendly web interface. Over the two-year period, we will attend multiple conferences, including but not limited to the Annual Meetings of the American Political Science Association (APSA), the International Studies Association (ISA), and the Midwest Political Science Association (MPSA). In the first year, we will present our work in progress to attain scholarly suggestions and feedback to improve our model and substantive work. In the second year, we will disseminate our estimates by introducing our packages and dashboard as well as presenting our substantive results.

Specifically, during the first year, we will focus on the estimates of public opinion by extensively expanding raw source data and survey items, including environment-related questions and respondents' demographics. In the second year, we will update the DCPO packages to measure polarization in climate change attitudes across different subpopulation groups across countries over time. Meanwhile, we will apply these estimates to study the dynamic relationship between climate change attitudes, polarization, and climate-policy adoption in cross-sectional time-series data. Additionally, PIs will take advantage of conference time for in-person, in-depth project meetings to exchange ideas and set the agenda.

Beyond conference presentations and three scholarly publications, we will disseminate our data through Dataverse, provide two updated DCPO packages, and develop a user-friendly dashboard. Climate scholars can download our estimates directly from Dataverse for use in downstream analyses. The updated DCPO packages will enable scholars to measure public opinion of their interests, from data collection and data wrangling to generating estimates. The user-friendly dashboard will be a valuable tool for the general public to explore temporal trends and compare spatial differences in public climate change attitudes, allowing users to visualize data based on their preferred time period, demographics, country, or region.

3 Timeline And Project Implementation

We propose a two-year project.

Fall 2025: Raw data collection.

Spring 2026: Document climate change public opinion estimates.

Summer 2026: Revise DCPO models and packages for estimating polarization.

Fall 2026: Estimate climate change polarization.

Spring 2027: Document climate change polarization estimates.

Summer 2027: Write up the paper about dynamic relationship between climate public opinion and climate policies.

4 Broader Impacts

The Climate Change Public Opinion Dataset (CCPOD) will serve as a crucial research infrastructure for researchers, educators, students, policymakers, non-governmental organizations, and news agencies worldwide, fostering both within and cross-national work on climate change, polarization, and broader public opinion. Through conference presentations, scholarly publications, and a user-friendly web interface, the dissemination of the resulting estimates will enhance the understanding of both scholars, policymakers, and general audience (like NGOs and Journalists) about the relationship between public opinion and climate policies, ultimately contributing to more informed and effective climate change action. In addition, two open-source R package for automatically data collection and measurement are made available so others can analyze similar data. This aligns with NSF's commitment to making knowledge accessible to policymakers, the public, and researchers. Moreover, this project will promote teaching by providing CCPOD's web-based graphical interface with user-friendly functionality to facilitate its use for teaching and learning data analytics and by employing graduate research assistants, especially members of marginalized groups, who will develop valuable new skills in this important interdisciplinary field.

5 Results From Prior NSF Support

We have received no prior NSF support. We are confident about the broad impact of our proposed project. Efficiently addressing climate change requires public support. Our project aims to fill the gap in public opinion data on climate change by estimating public opinion and polarization across countries over time. These estimates will be openly available and downloadable to everyone. Our web interface will facilitate the general public's understanding of climate change public opinion through customized visualizations.

The DCPO packages will be available to scholars, allowing them to measure public opinion and polarization in other fields. The success of the Standardized World Income Inequality Database (SWIID), a counterpart of DCPO that measures income inequality across countries over time, demonstrates the potential impact of our proposal. SWIID has been highly cited in SSCI, with 1,579 citations in Google Scholar and 133,990 downloads in Harvard Dataverse. This achievement underscores the potential reach and influence of our proposed project.

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