The Interactions of Social Norms about Climate Change: Science, Institutions and Economics

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Abstract

We study the evolution of interest in climate change among different actors within the population and how the interest of these actors affects one another. First, we document the evolution of interest for each actor individually, and then we provide a model of cross-influences between them. We estimate this model using a Vector Autoregression (VAR). We measure interest among the general public, the European Parliament, central banks, general interest science journals, and economics journals by creating a Climate Change Index (CCI) based on mentions of climate change in these domains. Except for general interest science journals, the index for all other domains has started showing significant values only recently, and it tends to fluctuate considerably. In terms of influence, the European Parliament and the media affect one another, but the trend in science remains relatively independent of the others.

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1 Introduction

"The furnaces of the world are now burning about 2,000,000,000 tons of coal a year. When this is burned, uniting with oxygen, it adds about 7,000,000,000 tons of carbon dioxide to the atmosphere yearly. This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few centuries."

August 14, 1912, Rodney & Otamatea Times "Science Notes and News"

As the quote above demonstrates, knowledge about anthropogenic climate change is not entirely new, nor is the understanding that it poses potential risks to humanity. Huntington (1917), writing in the *Quarterly Journal of Economics*, already suggested that climate change (though not necessarily anthropogenic in this instance) may have played a role in the decline of the Roman Empire.

Tackling this problem requires that regulators of different sorts make decisions that provide incentives for abatement. However, as the references above show, they have been very slow in doing so. The science about climate change has been available for a long time. So why does it seem that action is not happening quickly enough?

A first answer is that some action is already underway. Many regulators are aware of the problem. The European Commission, for example, has a Technical Expert Group on Sustainable Finance (TEG), which has produced numerous reports, and the Commission itself has, since 2018, promoted a very ambitious policy agenda, including landmark normative texts. These include an EU taxonomy to determine whether an investment is environmentally sustainable, an EU Green Bond Standard, methodologies for EU climate benchmarks, and corporate sustainability disclosures. All of this suggests that the policy response is underway in the European Union and other places and may follow elsewhere. However, the question remains: Why did this not happen much earlier, and how long will it take until there are significant effects?

Our hypothesis is that the evolution of social norms is a slow process, and their transmis-

sion between different social groups is also complicated. We start from a situation in which, as Carney (2015) pointed out, "The horizon for monetary policy extends out to 2-3 years. For financial stability, it is a bit longer, but typically only to the outer boundaries of the credit cycle – about a decade." If that is the status quo (social norm) regarding appropriate actions by central banks, it is difficult to expect regulators to start adopting a perspective that extends to half a century into the future or longer.

But even if norms are slow to change, they do change. A recent study (Eagly et al. (2020)) shows that women are now seen as equal to or more competent than men, something that didn't happen half a century ago. A similar shift has occurred with same-sex marriage. These changes in attitudes are now encoded in regulations fostering gender equality on corporate boards, as well as in laws allowing same-sex marriage. Social norms have also changed regarding environmental protection. In environmental protection, both farmers and businesses often go beyond legal mandates. And as Gunningham et al. (2004) say, "the increasing incidence of "beyond compliance" corporate behavior can be better explained in terms of the interplay between social pressures and economic constraints."

Our approach to answering the question of how norms change and diffuse between groups starts by proposing a model of norms' transmission in social networks. We assume that individuals take actions that have an idiosyncratic benefit and cost. In addition, there is complementarity between the actions of the individual and those of others in their group and in other groups that are "close" to them or whose opinions are important. The model has a simple linear quadratic structure (as in Ballester et al. (2006)) and delivers a unique equilibrium where the actions of group members depend on their idiosyncratic preferences and those of others in closely related groups. Given its structure, the model's parameters can be easily identified through an econometric model.

We complement the analytical framework for the problem with its empirical analysis. The aim of this part of the project is to ascertain the web of influences between different actors in climate change policy. We have collected information (using various databases and advanced web-scraping methods) about mentions of climate change and related terms

in mainstream news media from different countries, general interest scientific journals, top economics journals,[1] other economics journals, European Parliament questions, and various central bank presidential speeches since the 1990s. We then build a Vector Autoregressive (VAR) model to estimate how mentions by one actor in one period correlate with lagged mentions by other actors.

Our descriptive evidence reveals that natural scientists have been concerned about climate change for over 30 years. In contrast, academic economists in top journals remain largely unconcerned, though interest is growing outside these publications. The mainstream media and the European Parliament began addressing the issue seriously around the turn of the century. Central banks, however, have heightened their concern only recently.

In terms of the analytical results from the VAR, we study the data at a quarterly frequency. Three of our variables are mentions of climate change in different outlets: the news media, the European Parliament, and general interest scientific journals. We also use GDP as a control variable.

Our main finding with respect to the VAR is that the media and the European Parliament are mutually influenced. We also find significant interactions between all these variables and GDP shocks. This might seem concerning, as a long-term problem like climate change should command a steady stream of interest and resources. However, our findings may provide a tool for concerned organizations to optimally allocate their resources at the most appropriate times.

We cannot find strong influences of science on the media or the European Parliament. While it is possible that scientific efforts are not very impactful in this domain, we should be cautious in interpreting this result. It could also be that the influences are more subtle than our statistical model can capture, or that the data needed to detect such influence are more granular than what we have used.

[1] The so-called Top 5: *Quarterly Journal of Economics*, *American Economic Review*, *Journal of Political Economy*, *Econometrica* and *Review of Economic Studies*.

1.1 Related literature

This paper contribute to several strands of the literature. One of them is the related to social norms. Fehr and Schurtenberger (2018) have argued that many regularities regarding cooperation can be explained if individuals hold a social norm of conditional cooperation. (Kimbrough and Vostroknutov (2016) and Kölle et al. (2020), Szekely et al. (2021) provide evidence of norm-following that leads to cooperation.) In fact, social norms have been proposed as a key instrument to solve social dilemmas in general (Ostrom (2000); Bicchieri (2005); Biel and Thøgersen (2007)) and climate change in particular Riehm et al. (2020). We contribute to this literature by providing a comprehensive model and empirical evidence that demonstrate how these norms disseminate and become established within the population.

We also contribute to a large literature about the media communication of climate change (Wilson (2013), Gavin (2009) or Engle et al. (2020)). We contribute to this literature by providing a comprehensive analysis of the evolution of climate change coverage and its interaction with other domains. A similar contribution is provided to the literature on scientific journal's coverage of climate change (including the surprisingly low coverage in top economics journals) as in Nielsen and Schmidt Kjærgaard (2011), Ladle et al. (2005), Oswald and Stern (2019), or in political circles Willis (2017), Willis (2018), and central banks Olovsson (2018), Skinner (2021).

Our method for creating indices is taken from Baker et al. (2016) and Ghirelli et al. (2021) but applied to a different field. Our theoretical model is inspired by the work in social networks pioneered by Ballester et al. (2006).

2 Developing a Climate Change Index of Public Interest

This section conducts a systematic examination of how various sectors—namely the news media, the European Parliament, scientific journals, economic publications, and Central Banks—engage with the issue of climate change. By tracking the frequency of climate change-related terms, we establish an empirical measure of the concern attributed to this

issue within each sector, providing a lens through which we can assess the broader economic and policy implications.

2.1 Media Coverage of Climate Change

We analyze the presence and evolution of Climate Change awareness over time across different countries. Baker et al. (2016) successfully measures an unobservable variable, such as uncertainty in Economic Policy, with a concept as simple as it is powerful: The impact of this variable is reflected in the frequency of terms related to economic uncertainty in various newspapers over time. The higher the frequency of these terms, the more significant the impact or the more heightened the interest in that variable during the corresponding period.

We similarly construct a Climate Change Index (CCI) based on an extensive dataset of news articles from leading newspapers, focusing specifically on the term "climate change." The precise nature of this keyword ensures that any mention within the text directly relates to the issue, allowing for clear and straightforward identification. Additionally, the widespread use of the term "climate change" across different languages facilitates consistent cross-country comparisons, making it an effective tool for international analysis.[2] Using a more complex structure would not allow us to make such comparisons using texts. Nevertheless, to ensure robustness, we replicated the analysis using an extended set of climate change-related vocabulary, yielding consistent results. The set of keywords we used for this additional analysis is detailed in Appendix A.

Building on this approach, we used data from Dow Jones Factiva,[3] extracting mentions of climate change across 69 prominent newspapers worldwide. This extensive dataset encompasses 18 UK newspapers, 18 European newspapers, 12 US newspapers, 7 Australian newspapers, 7 Indian newspapers, 5 Canadian newspapers, and 2 Singaporean newspapers.[4]

[2]We use "Changement Climatique" for French, "Klimawandel" for German, "Cambiamento Climatico" for Italian, and "Cambio Climático" for Spanish.

[3]Dow Jones Factiva is a premier international news database produced by Dow Jones. This database aggregates over 30,000 sources, from 200 countries in 32 languages. Users can explore a wide range of information, including newspapers, newswires, industry publications, websites, and company reports.

[4]The complete list of newspapers is provided in Appendix B.

For most of these publications, our records begin in 1995, based on the availability of data. This comprehensive and geographically diverse dataset allows us to capture a wide range of regional perspectives on climate change over time.

We standardize the monthly shares of the newspaper-level series to a unit standard deviation for 1995-2023. Next, we calculate the monthly average across all countries. Finally, this average is normalized by dividing by the mean and multiplying by 100 for the same period, producing the standardized series.

Figure 1: Monthly Climate Change Index for Europe

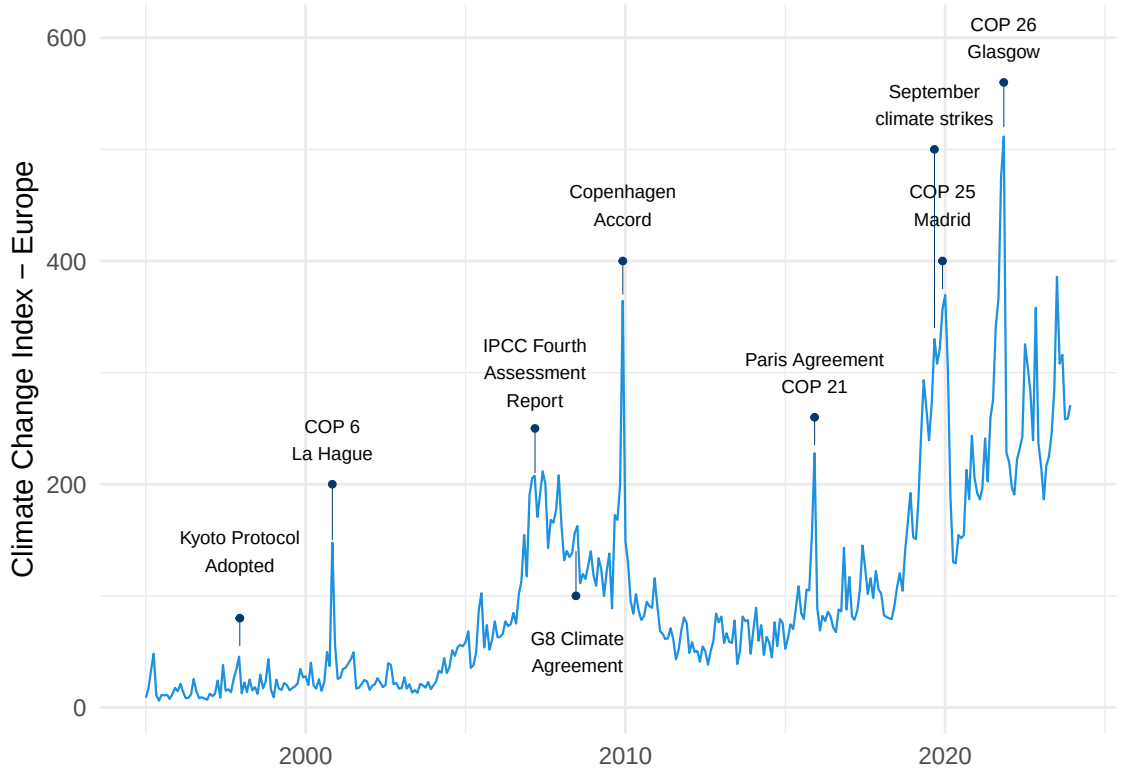


Figure 1 shows the Climate Change Index for Europe. Media attention to climate change remains negligible until approximately the year 2000. It is not until around 2015 that climate change emerges consistently as a significant topic. The media's narrative on climate change is characterized by intermittent surges in coverage, followed by periods of diminished focus, despite the fact that the underlying issue continues to deteriorate rather than improve.

Interestingly, climate change did not gain significant media attention until after 2000,

despite the Kyoto Protocol being signed in 1997. The Kyoto Protocol marked a significant commitment by developed countries to substantially reduce their greenhouse gas emissions, as outlined by the United Nations Framework Convention on Climate Change. However, this major international agreement seemed to go largely unnoticed by the mainstream media at the time.

The first significant peak in European media coverage emerges in November 2000, aligning with the Climate Change Conference at The Hague. This pattern, observed across the entire sample, suggests that media interest is driven by specific events rather than reflecting a sustained structural focus on climate change. The Hague conference, attended by representatives from over 150 countries, aimed to finalize the mechanisms and targets for reducing greenhouse gas emissions as outlined in the Kyoto Protocol. Despite the considerable political attention, the conference ended without reaching a consensus, ultimately being viewed as a failure.

The next notable surge in media coverage occurred in November 2006, closely following the mid-year release of the documentary "An Inconvenient Truth." This film, led by former U.S. Vice President Al Gore, sought to raise public awareness about global warming by presenting the latest scientific evidence, a move that sparked significant controversy. Concurrently, the United Nations Climate Change Conference took place in Nairobi, Kenya, featuring the 12th Conference of the Parties to the UNFCCC (COP12) and the second Meeting of the Parties to the Kyoto Protocol (MOP2). This period saw an increase in both media and political discourse, coinciding with critical deadlines for Kyoto Protocol members to make tangible commitments. However, despite some minor agreements, the conference ultimately failed to produce substantial progress in the fight against climate change, much like the outcome in 2000.

Media interest diminishes once again until 2009, when a series of significant events triggered the most substantial peak in coverage up to that point. As in 2000 and 2006, this surge coincided with a controversial situation, this time centered around the so-called "Climategate," which intertwined science and climate change in a contentious manner. "Cli-

mategate" was a controversy that erupted in November 2009, when a large number of emails and documents from the Climatic Research Unit (CRU) at the University of East Anglia were hacked. The leaked material was interpreted by some as proof that climate scientists were manipulating data to exaggerate the threat of global warming. Although several independent investigations eventually cleared the scientists, the Climategate incident fueled skepticism and debate about climate science, particularly as the 2009 United Nations Climate Change Conference in Copenhagen approached. This conference was intended to establish a framework for climate change mitigation beyond 2012. As in previous instances, the timing marked a critical decision point on climate policy. Despite a final consensus among the United States, China, India, Brazil, and South Africa, no binding agreement was reached, rendering the conference another failure, despite its global significance.

Following these events, media interest in climate change appeared to diminish entirely until late 2015, coinciding with the United Nations Climate Change Conference in Paris. This raises the question: What might have occurred had the press maintained the momentum of the climate change debate during those intervening years? Could sustained media focus have exerted greater influence on the political sphere? It is also worth considering that the economic recession during this period may have adversely affected the level of media interest in climate change, as attention shifted toward more immediate economic concerns.

Fortunately, by the end of 2015, the Paris conference yielded the first global agreement to reduce emissions. This agreement, a binding international treaty, marked a significant milestone as, for the first time, the signatories collectively committed to:

- Substantially reduce greenhouse gas emissions to limit the global temperature increase this century to 2 °C and strive to limit this increase even more, to just 1.5 °C.
- Review the individual country commitments every five years.
- Provide financing to developing countries to enable them to mitigate climate change, strengthen resilience and improve their capacity to adapt to the impacts of climate change.

It is striking that the 2009 peak in media coverage, occurring despite the failure to secure an agreement, exceeds the peak associated with the 2015 Paris Agreement, a landmark event where a global accord was finally reached. This is probably due to the same reason voter turnout is higher in close elections. Participation in a public event is higher when people feel pivotal.[5] Following the 2015 peak, the CCI index experiences another decline. However, this time the descent is more gradual, suggesting a sustained, albeit reduced, level of media engagement compared with the sharper declines observed in previous years.

Beginning in 2018, we observe a pronounced increase in interest in climate change, reflected in both media coverage and policymaking circles. This period is marked by heightened debate, coinciding with the 2018 United Nations Climate Change Conference, where new agreements were reached. Notably, this era also saw the rise of influential figures such as Greta Thunberg, whose activism garnered substantial media attention, particularly her transatlantic voyage by boat to attend the 2019 climate summit in the United States. While it is difficult to disentangle circumstantial from structural drivers of media interest during this period, our index reveals a sharp decline following the conclusion of the 2019 summit, well before the onset of the Covid-19 pandemic.

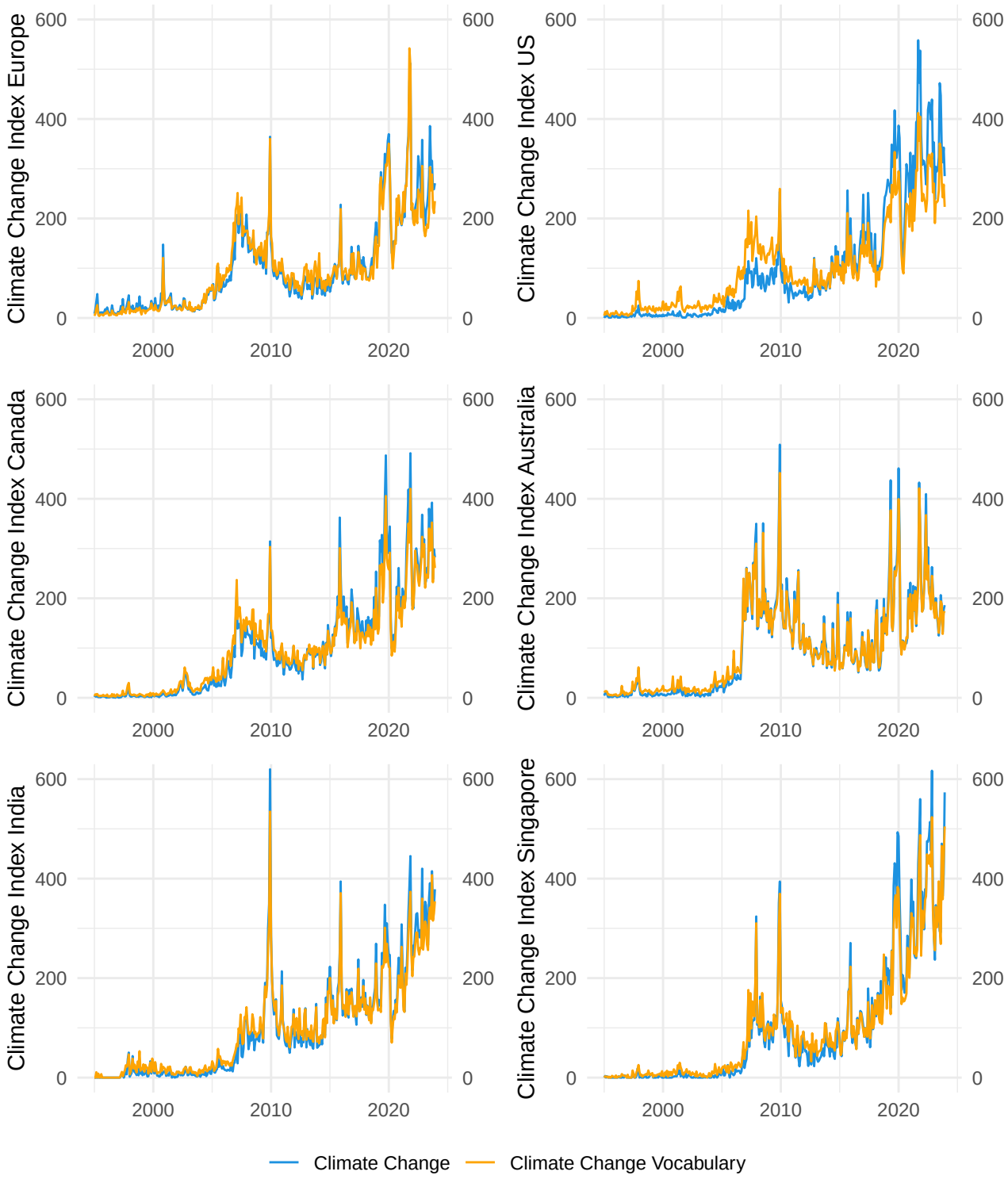
Interestingly, with the onset of the pandemic, the index begins to rise once more, eventually reaching the highest point in the series. This peak occurs in November 2021, aligning with the United Nations Climate Change Conference, which is customarily held in November.

Figure 2 illustrates the index across various countries, uncovering a remarkable consistency in patterns despite differing national contexts. In most cases, there is minimal engagement with climate change until 2005, followed by a significant peak in 2006 and a subsequent decline. From that point onward, a sustained upward trajectory is observed. However, Australia diverges notably, exhibiting a relatively stable level of interest since 2006, in contrast to broader global trends.

In 2009, India's heightened concern over climate change was driven by its acute vul-

[5]For a metanalysis of results on this topic see e.g. Cancela and Geys (2016).

Figure 2: Monthly Climate Change Index for Different Countries



nerability to climate impacts, coupled with significant international pressure during the Copenhagen Climate Conference. The challenge of reconciling economic growth with sustainable development, alongside the introduction of the National Action Plan on Climate Change and a growing public consciousness, further intensified the focus on climate issues.

Moreover, a shift in linguistic patterns is discernible in the United States. Prior to 2015, the term "global warming" was more common than "climate change," a trend that diminishes thereafter. This linguistic shift is unique to the U.S., as it is not mirrored in other countries within the sample.

2.2 Climate Change and Economics journals

We start with the so-called Top 5 journals.[6] Their significance in Economics is well-established. As noted by Heckman and Moktan (2020), these publications exert substantial influence on tenure decisions and the likelihood of securing tenure, with research proposals often evaluated based on their potential to yield Top 5 publications. Analyzing the prominence of climate change within these journals provides one important indication about the status of climate change as a frontier issue in economic research.

We thus analyzed the number of papers published in the Top 5 Economics journals that mention "Climate Change" in their title or abstract from 1999 to 2023[7] (see table 1). The results offer insight into the interest economists have shown toward this issue. However, it is important to acknowledge a limitation: Our data is confined to published papers, which leaves the influence of referees and editors largely unexamined, as we do not have access to submission records. Consequently, it is plausible that climate change-related papers represent a greater share of total submissions than is reflected in the published output.

Remarkably, our analysis reveals that only 19 papers published between 1999 and 2023 include "Climate Change" in the title or abstract. Of these, two are corrections to an original

[6]The top journals are: The American Economic Review (AER), Econometrica (ECMA), the Journal of Political Economy (JPE), the Quarterly Journal of Economics (QJE), and the Review of Economic Studies (ReStud).

[7]It should be noted that papers from AER P&P were excluded as they are not technically classified as AER articles.

article with errors, and three are part of a special issue on climate change. Therefore, the "real" number of articles specifically addressing climate change is considerably lower, with half of these articles appearing in the past five years. This analysis was conducted on a dataset comprising over 7,400 papers.

The identification method may have influenced the results, as papers on emissions, Pigouvian taxes, or broader environmental issues could be tangentially related to climate change. However, it is crucial to recognize that climate change is a distinct issue. If a paper does not explicitly mention it in the title or abstract, the author does not consider the paper's implications for climate change as something relevant enough to be mentioned, and thus the paper is unlikely to address the issue directly.[8] Even when considering climate change alongside other related terms in Top 5 journals (what we call Climate Change Vocabulary), it remains significantly less prominent than topics like Monetary Policy or Unemployment, and Climate Change alone is less popular than Marketing or Transportation. Table 1 compares various keywords, reinforcing this point and providing a benchmark against terms such as unemployment, inflation, institutions, or monetary policy.

Nevertheless, considering the lengthy publication process in Economics, working papers might serve as a more accurate metric than published articles. Additionally, different patterns may emerge outside the Top 5 journals, where the dynamics of research dissemination can differ. To address these issues, and as an alternative to the narrow focus on the Top 5, RePEc[9] data are utilized for the analysis, revealing a distinct pattern. Figure 3 illustrates the percentage of papers by RePEc users that include climate change terms in their titles or abstracts. In contrast to the Top 5 journals, these data reveals a distinct upward trend beginning around 2005. This suggests that climate change is increasingly relevant for some

[8]While top economics journals have given limited attention to climate change, the literature on the subject is extensive, as evidenced by Desmet and Rossi-Hansberg (2024) or Fernández-Villaverde et al. (2024).

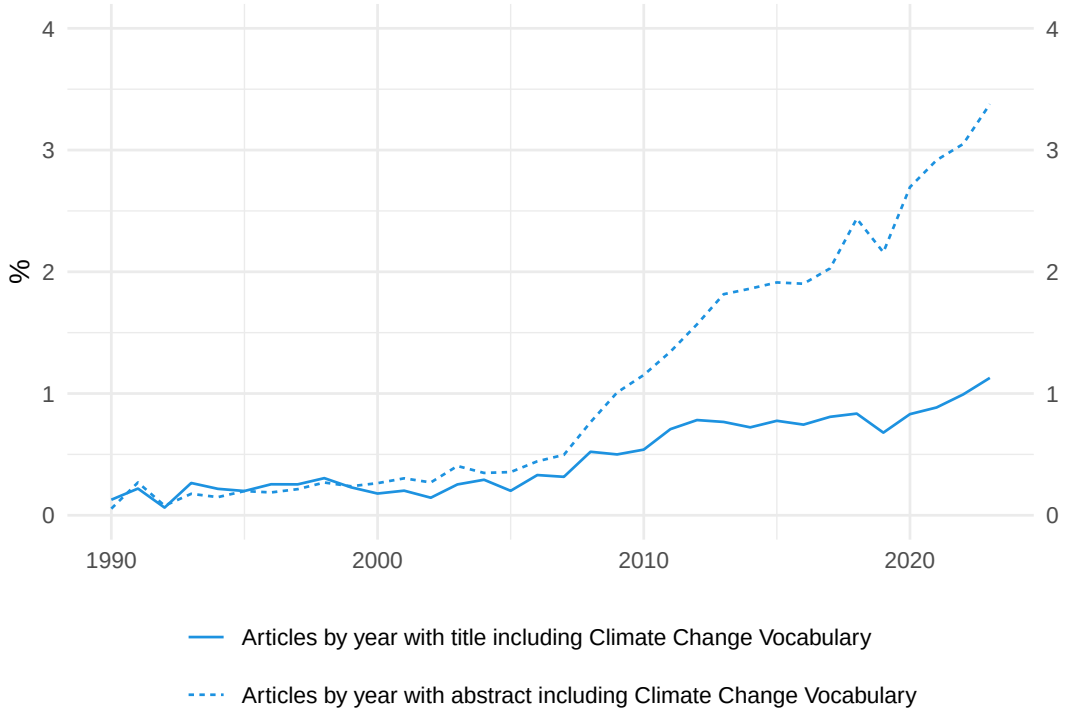
[9]For more details, see http://repec.org/. RePEc, dedicated to enhancing the dissemination of economic research, compiles metadata from over 2,000 publishers, encompassing academic and commercial publishing houses, research organizations, policy institutions, and think tanks. This extensive database covers virtually all relevant journals and a significant number of working papers (pre-prints) from various institutions, with more than 60,000 economists registered.

economists, but it is not viewed as one of the most relevant/urgent issues in mainstream economics.

Table 1: Count of Words in the Top-5 Journals in Economics (Abstract and/or Title - 1999-2023

	Count	Share
Climate Change	19	0.25
Climate Change Vocabulary	34	0.46
Systemic Risk	8	0.11
Environmental	71	0.95
Pollution	44	0.59
Carbon Tax	9	0.12
Unemployment	172	2.30
Marketing	27	0.36
Monetary Policy	178	2.38
Game Theory	23	0.31
Optimal Policy	66	0.88
Inflation	172	2.30
Tax	336	4.50
Inequality	285	3.82
Transportation	23	0.31
Institutions	156	2.09

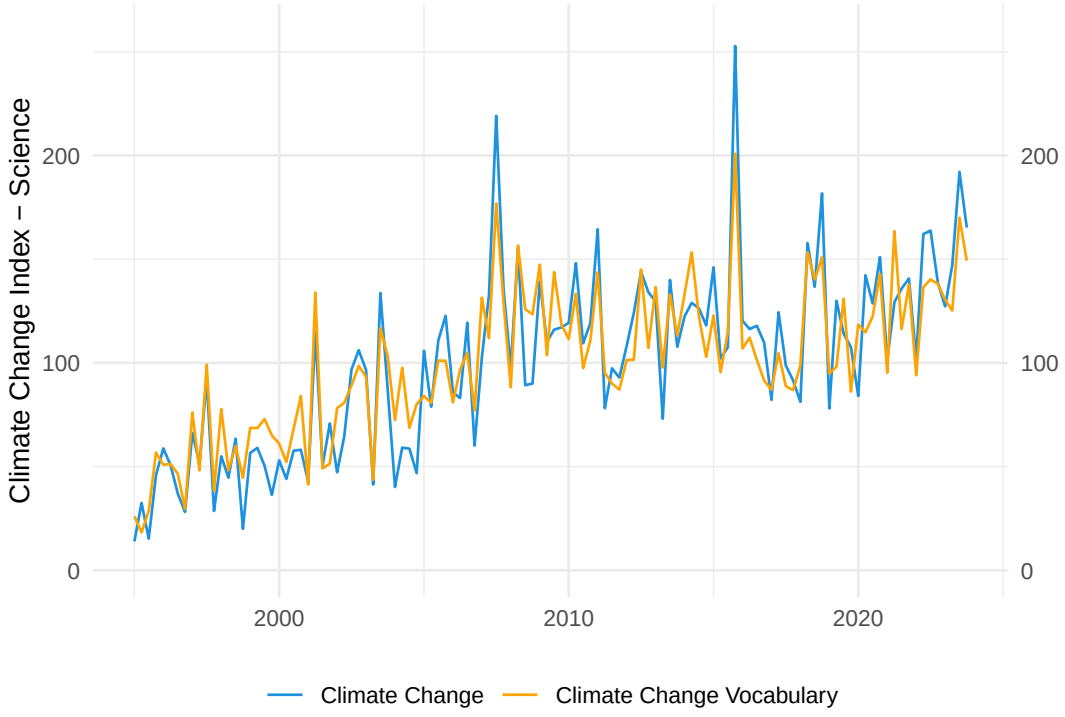
Figure 3: RePEc Share of Articles Using Climate Change.



2.3 Climate Change and General Interest Scientific Journals

Following the methodology applied to the Climate Change Index (CCI) in the media, an index was constructed using data from major General Interest Scientific Journals—*Nature*, *Philosophical Transactions A*, *Proceedings of the National Academy of Sciences*, and *Science*—covering the period from 1995 to 2023. Figure 4 shows the resultant index, based on mentions of climate change and related vocabulary. The results indicate a steady and consistent increase in interest in climate change over time, generally around the mean for the period. This contrasts with media and political perspectives, which seem to react more to behavioral and event-driven criteria. Moreover, the most influential science journals show a clear interest in climate change, in contrast to the most influential economics journals, where the interest measured in these terms is very low.

Figure 4: Quarterly Climate Change Index for the General Interest Science Journals.



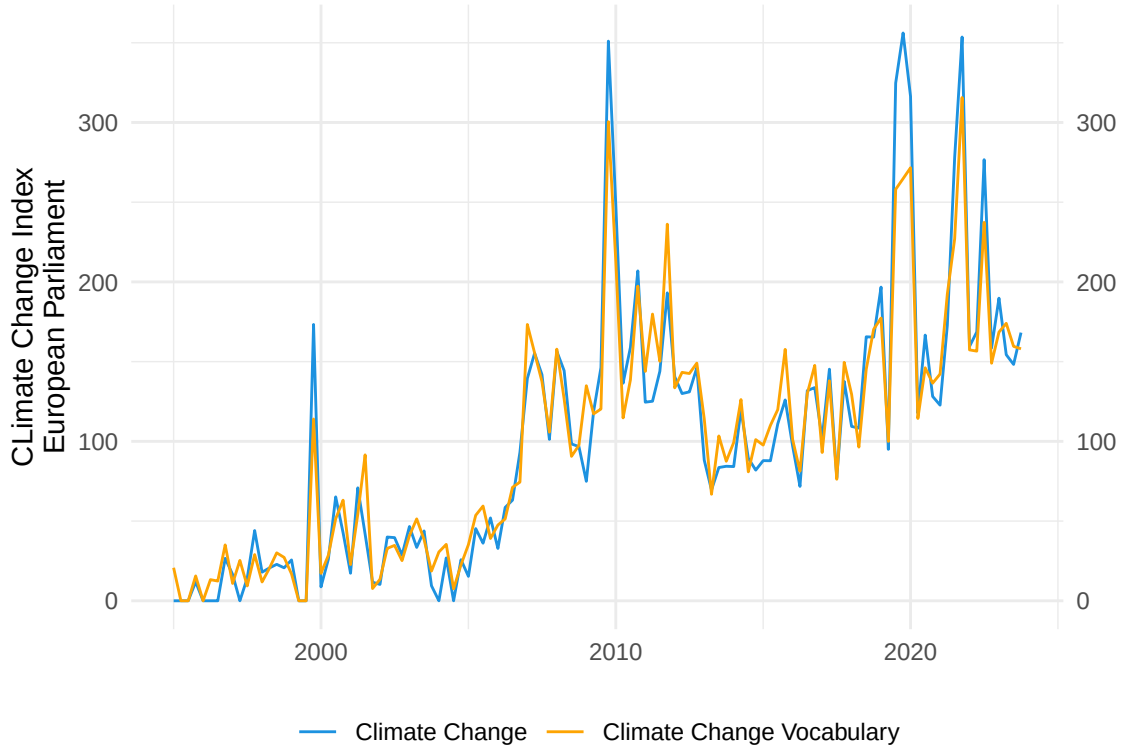
2.4 Policymakers' concern about climate change

2.4.1 European Parliament

To assess policymakers' interest in climate change, we developed a new source of information based on written questions submitted by members of the European Parliament. Any Member, political group, or parliamentary committee can direct questions requiring written responses to the heads or members of European Institutions, including the President of the European Council, the Council, the Commission, or the Vice-President of the Commission/High Representative of the Union for Foreign Affairs and Security Policy, or the President of the European Central Bank. These questions typically address issues of concern to EU citizens. Consistent with our previous analyses, we examined the frequency of the terms "climate change" and related vocabulary.

Figure 5 exhibits a pattern similar to that in Figure 1, reflecting media interest in climate change. The figure is characterized by high peaks followed by periods of reduced attention.

Figure 5: Quarterly Climate Change Index for the European Parliament



Interest was minimal before 2005, but a consistent upward trend has been observed since then. Notable spikes occurred around the Copenhagen Accord, with sustained high levels of interest since 2018.

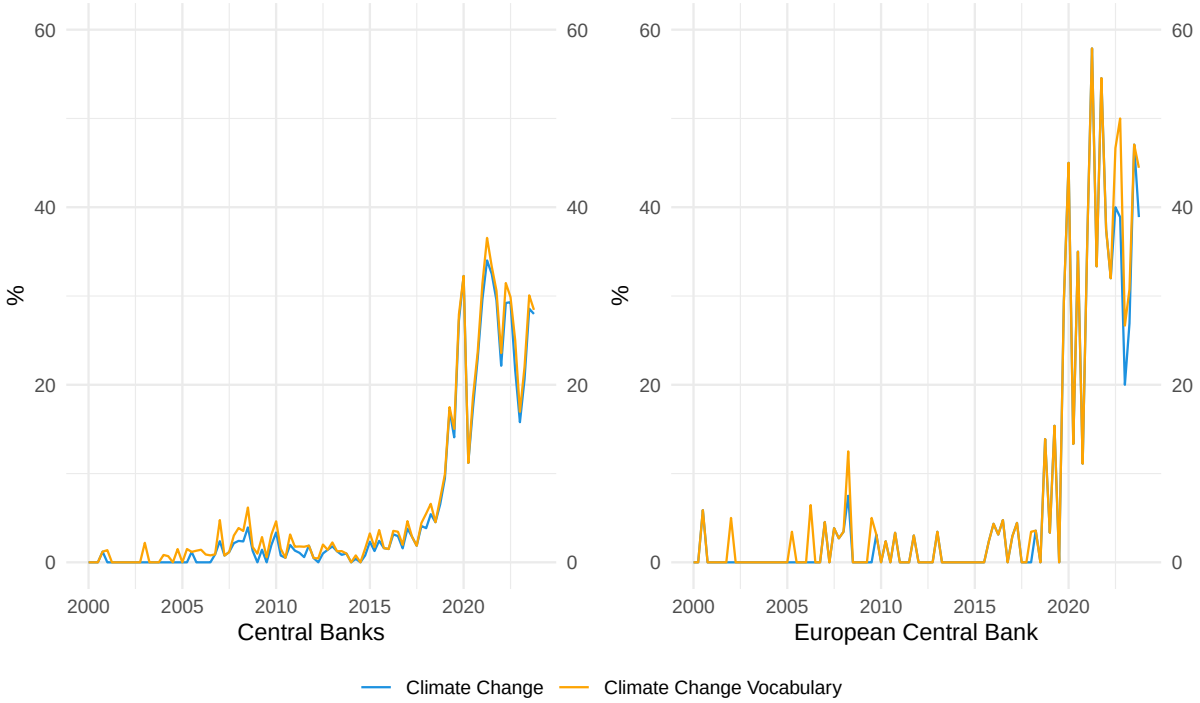
2.4.2 Central Bank Speeches

Similarly, Figure 6 analyzes the proportion of ECB presidential speeches[10] in English that reference "climate change" and related vocabulary since the institution's inception in 1997. Additionally, we examine over 17,000 English-language speeches from central bankers, including those from the Federal Reserve, ECB, and other central banks, as documented in the Bank for International Settlements (2024).[11]

Until 2018, mentions of climate change were rare, underscoring a lack of interest in the topic. However, since 2019, over 50% of ECB speeches and approximately 25% of all central

[10] Available at ECB site.
[11] The BIS.

Figure 6: Share of Speeches Containing the Words "Climate Change"



bankers' speeches have included these terms. This significant shift indicates that climate change has swiftly emerged as a critical issue for central banks. Due to the recentness of the data, the full impact of this trend cannot yet be thoroughly analyzed in this paper.

2.4.3 The Federal Open Market Committee - FOMC

In contrast to the Central Bank speeches, we examined the frequency of "climate change" mentions in the Federal Open Market Committee (FOMC)[12] transcripts from 1975 to 2018, which are released with a five-year lag. The term "Climate Change" appears only once in this period in a climate-related context. Similarly, in the FOMC minutes published from 1993 to the present, it is mentioned only three times in 2019, 2020, and 2023. This highlights a stark difference in the attention given to climate change by the FOMC compared with other central banking institutions.

[12]The Federal Open Market Committee (FOMC) is the institution of the Federal Reserve System responsible for overseeing U.S. monetary policy. It conducts open market operations, primarily by setting the federal funds rate target range, to influence economic conditions, especially inflation and employment.

3 A simple theoretical framework

To understand the relationship between different institutions and the social group whose preoccupation with climate we characterize with their public utterances, we first describe a tractable model based on Ballester et al. (2006) whose parameters we later estimate using a vector auto-regression (VAR).

Every individual j belongs to some group G_j where $|G_j| \in \mathbb{N}$. A parameter $\lambda_{G_iG_j}$ measures how a group i person cares about a group j person (as in Ballester et al. (2006), equilibrium existence requires that $\lambda_{G_iG_j}$ are small enough). Every individual experiences an idiosyncratic amount of intrinsic interest in the policy b_i. There is a costly action a_{i_t} that each individual takes in every period t. This action has a cost per unit c_i. Let $\mathbf{a_{-i_t}}$ be the vector of actions of players other than i at time t. With these elements in place, we can write the utility function as:

$$U_i\left(a_{i_t}, \mathbf{E}(\mathbf{a_{-i_t}})\right) = a_{i_t}\left(b_i + \sum_{j \in R} \lambda_{G_iG_j} E(a_{j_t})\right) - \frac{c_i}{2} a_{i_t}^2$$

Then, if $E(a_{j_t}) = f(a_{j_{t-1}}, a_{j_{t-2}}, ..., a_{j_{t-k}})$, that is, if people form expectations using past actions of other agents, the optimal action can be written as:

$$a_{it} = \frac{1}{c_i}\left(b_i + \sum_{j \in R} \lambda_{G_iG_j} f(a_{j_{t-1}}, a_{j_{t-2}}, ..., a_{j_{t-k}})\right)$$

Then, if $f(a_{j_{t-1}}, a_{j_{t-2}}, ..., a_{j_{t-k}}) = \delta_1 a_{j_{t-1}} + ... + \delta_k a_{j_{t-k}}$ is a linear function, the optimal action for each individual can be written as:

$$a_{it} = \frac{1}{c_i}\left(b_i + \sum_{j \in R} \lambda_{G_iG_j} (\delta_1 a_{j_{t-1}} + ... + \delta_k a_{j_{t-k}})\right)$$

And since the individual actions are linear in others' previous actions, we can aggregate to an institutional level. (A key assumption in this case is that the interaction parameters

$\lambda_{G_iG_j}$ are common within groups.) Given this, the VAR constant in the equation for each group's "action" (the number of messages) is b_i/c_i, i.e. the intrinsic interest in the policy (relative to the cost of messaging), and a coefficient of the action of other groups at lag k is $\lambda_{G_iG_j}\delta_k/c_i$, i.e. the impact on the marginal benefit of group G_i of an increase in G_j action (relative to the cost) times the importance of lag k in the expectations.

4 VAR model estimation

To understand the interconnection between the different actors we estimate a VAR micro-founded from the model in Section 3. It can be written as $X_t = \Pi(L)X_t + \epsilon_t$, where X_t is a set of endogenous variables, Π is a matrix of VAR coefficients capturing the dynamics of the system, and $\epsilon_t : N(0, \Sigma)$ is a vector of shocks having zero mean and variance–covariance matrix Σ. The variables in X_t are defined as follows: x_1 represents our index for climate change in the media, x_2 corresponds to our index for climate change mentions in European Parliament questions, and x_3 reflects the ones obtained from scientific journals. Additionally, x_4 corresponds to GDP for the Euro Area, serving as a control for economic activity.[13]

Table 2 displays the results. The notation ARx (y,z) means that "x" is the lag, "y" is the index of the variable whose effect we measure, and z is the index of the variable affected by it. The data are quarterly, with each quarter showing that the European Parliament and GDP are influenced by their own lags. Notably, the European Parliament exerts a positive influence on the media, indicating that increased debate on climate change within the Parliament leads to heightened media interest in the subsequent quarter. Conversely, scientific publications have a negative impact on media interest, suggesting that a rise in climate change articles corresponds to a decline in media attention in the following quarter. GDP positively influences scientific output, indicating that during periods of economic expansion, the scientific community pays greater attention to climate change, while this

[13]To satisfy the stationarity requirements necessary for VAR model estimation, we first removed any linear trends from the data. Following this detrending process, we employed the Augmented Dickey-Fuller (ADF) test to verify that the series had achieved stationarity.

focus diminishes during recessions. In contrast, GDP has a negative impact on the European Parliament's attention to climate change, suggesting that economic growth reduces parliamentary focus on the issue, with increased attention during economic downturns.

At two quarters, the variables exhibit no own effects. Notably, there is a negative impact of media on the European Parliament, indicating a reduction in parliamentary focus on climate change after a burst in media attention half a year before. The influence of GDP on the European Parliament persists over two quarters.

At three quarters, only the media exhibits own effects. By four quarters, the European Parliament becomes the sole variable with a persistent own effect. Media positively influences the European Parliament, while the European Parliament, in turn, exerts a negative effect on media. Additionally, GDP exerts a positive influence on the European Parliament and a negative influence on media.

It is sometimes complicated to interpret coefficients separately, especially when, as it happens in our case, the same two variables show at one lag a positive coefficient and then a negative one. This could simply be the product of dampening cyclic patterns. That is why it is interesting to also present the impulse response functions.

In Figure 7 it is easy to observe that shocks to interest in media and parliament clearly influence one another. Science, on the other hand, seems to be largely isolated of the movements of interest in media and politics, and vice versa.

Shocks to GDP, on the other hand, have substantial influence on the other variables in the long run, as shown in Figure 8.

Figure 7: Impulse Response Functions 1.

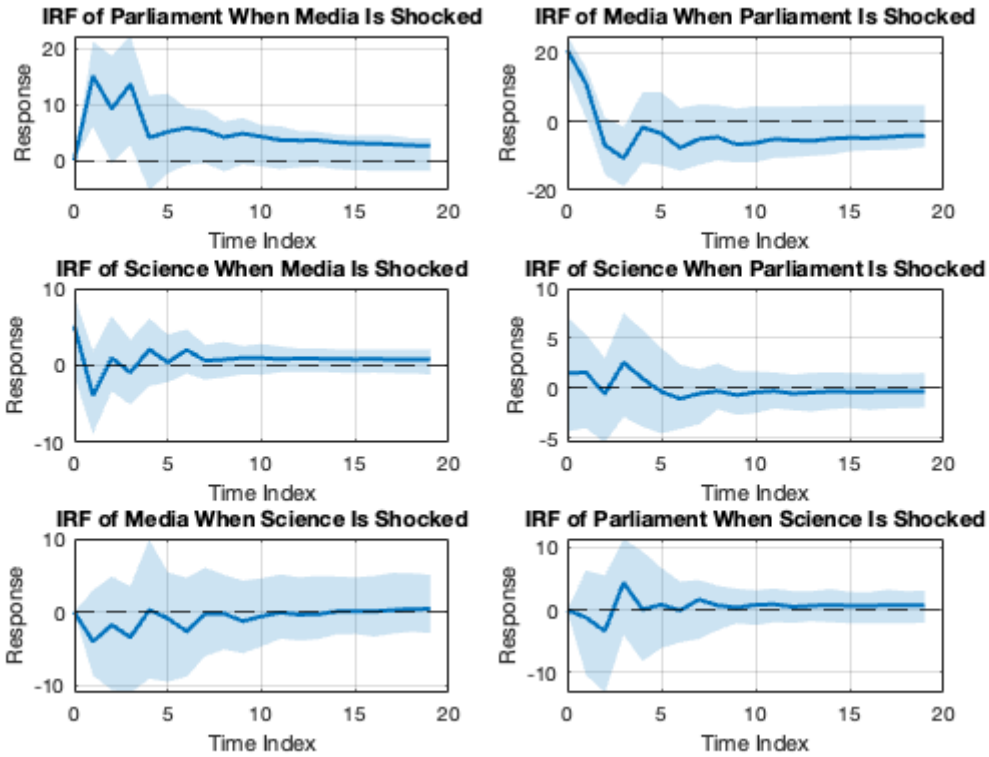


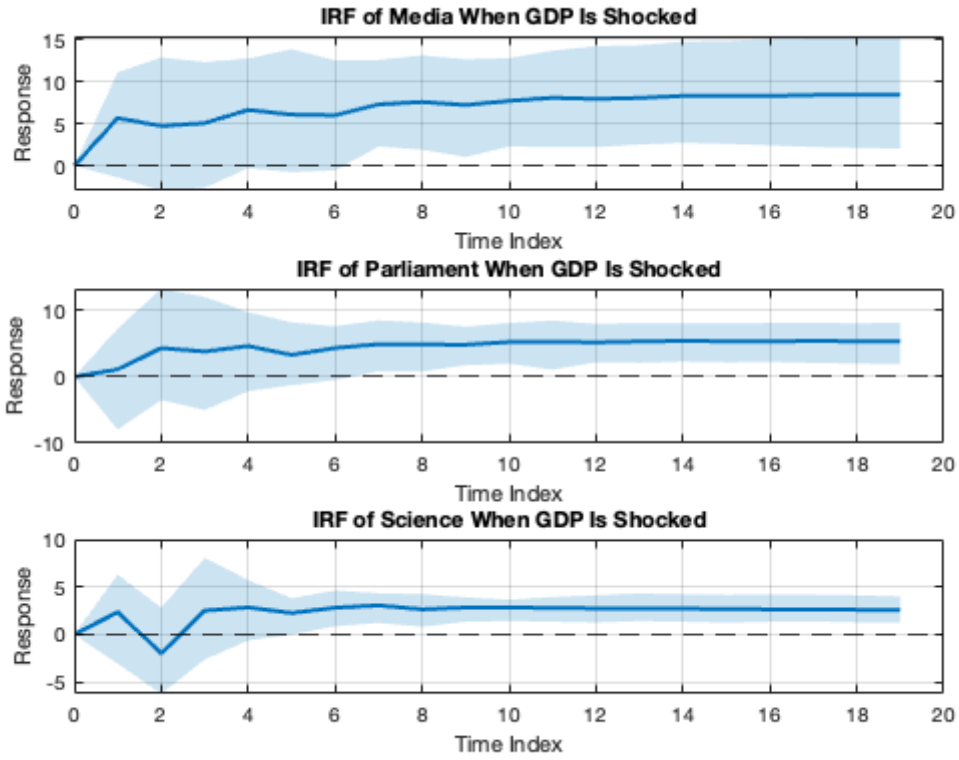
Table 2: VAR: AR{x}(y,z) - where "x" represents the lag, "y" is the affecting variable, and "z" is the affected variable.

	Value	Std. Error	T-Statistic	P-Value
Constant(1)	-0.594	4.360	-0.136	0.892
Constant(2)	0.495	3.580	0.138	0.890
Constant(3)	0.766	2.739	0.279	0.780
Constant(4)	0.048	0.139	0.342	0.733
AR{1}(1,1)	0.238**	0.112	2.119	0.034
AR{1}(2,1)	-0.07	0.092	-0.760	0.447
AR{1}(3,1)	0.09	0.070	1.280	0.200
AR{1}(4,1)	-0.008**	0.004	-2.334	0.020
AR{1}(1,2)	0.476***	0.139	3.419	0.001
AR{1}(2,2)	0.646***	0.114	5.653	0.000
AR{1}(3,2)	-0.154*	0.087	-1.767	0.077
AR{1}(4,2)	-0.002	0.004	-0.464	0.643
AR{1}(1,3)	-0.039	0.153	-0.255	0.799
AR{1}(2,3)	-0.146	0.125	-1.164	0.244
AR{1}(3,3)	0.094	0.096	0.982	0.326
AR{1}(4,3)	0.011**	0.005	2.269	0.023
AR{1}(1,4)	0.913	2.919	0.313	0.754
AR{1}(2,4)	3.428	2.397	1.430	0.153
AR{1}(3,4)	1.664	1.834	0.907	0.364
AR{1}(4,4)	0.71***	0.093	7.614	0.000
AR{2}(1,1)	-0.085	0.119	-0.720	0.471
AR{2}(2,1)	-0.318***	0.097	-3.265	0.001
AR{2}(3,1)	-0.046	0.074	-0.622	0.534
AR{2}(4,1)	-0.008**	0.004	-2.076	0.038
AR{2}(1,2)	-0.138	0.167	-0.824	0.410
AR{2}(2,2)	0.174	0.137	1.269	0.205
AR{2}(3,2)	0.108	0.105	1.031	0.303
AR{2}(4,2)	0.009	0.005	1.613	0.107
AR{2}(1,3)	-0.041	0.157	-0.261	0.794
AR{2}(2,3)	-0.003	0.129	-0.025	0.980
AR{2}(3,3)	-0.014	0.099	-0.138	0.890
AR{2}(4,3)	0.004	0.005	0.749	0.454
AR{2}(1,4)	0.419	3.494	0.120	0.905
AR{2}(2,4)	-2.092	2.869	-0.729	0.466
AR{2}(3,4)	-2.231	2.195	-1.016	0.309
AR{2}(4,4)	0.134	0.112	1.203	0.229

Table 3: VAR: AR{x}(y,z) - where "x" represents the lag, "y" is the affecting variable, and "z" is the affected variable.

	Value	Std. Error	T-Statistic	P-Value
AR{3}(1,1)	0.137	0.122	1.125	0.261
AR{3}(2,1)	-0.157	0.100	-1.571	0.116
AR{3}(3,1)	0.034	0.076	0.451	0.652
AR{3}(4,1)	-0.006	0.004	-1.506	0.132
AR{3}(1,2)	0.17	0.163	1.042	0.297
AR{3}(2,2)	0.358***	0.134	2.676	0.007
AR{3}(3,2)	-0.051	0.102	-0.497	0.619
AR{3}(4,2)	0.007	0.005	1.287	0.198
AR{3}(1,3)	0.182	0.156	1.169	0.243
AR{3}(2,3)	-0.105	0.128	-0.820	0.412
AR{3}(3,3)	0.092	0.098	0.942	0.346
AR{3}(4,3)	-0.005	0.005	-0.941	0.347
AR{3}(1,4)	0.122	3.496	0.035	0.972
AR{3}(2,4)	-0.555	2.870	-0.194	0.847
AR{3}(3,4)	2.242	2.196	1.021	0.307
AR{3}(4,4)	0.142	0.112	1.269	0.205
AR{4}(1,1)	0.272**	0.125	2.170	0.030
AR{4}(2,1)	0.264**	0.103	2.559	0.010
AR{4}(3,1)	-0.054	0.079	-0.682	0.495
AR{4}(4,1)	0.015***	0.004	3.809	0.000
AR{4}(1,2)	-0.357**	0.153	-2.332	0.020
AR{4}(2,2)	-0.203	0.126	-1.613	0.107
AR{4}(3,2)	0.092	0.096	0.961	0.337
AR{4}(4,2)	-0.012**	0.005	-2.537	0.011
AR{4}(1,3)	0.013	0.155	0.081	0.935
AR{4}(2,3)	0.142	0.127	1.116	0.264
AR{4}(3,3)	0.002	0.097	0.021	0.983
AR{4}(4,3)	0.001	0.005	0.208	0.835
AR{4}(1,4)	-0.461	2.853	-0.162	0.872
AR{4}(2,4)	0.408	2.342	0.174	0.862
AR{4}(3,4)	0.484	1.792	0.270	0.787
AR{4}(4,4)	-0.141	0.091	-1.550	0.121

Figure 8: Impulse Response Functions 2.



Summarizing our observations:

Remark 1 *Our analysis reveals a reciprocal relationship between media and the European Parliament, with each influencing the other. We also observe significant interactions among the three variables (Media, Parliament and Science) and GDP shocks.*

This is a cause for concern, as attention to a long-term issue like climate change should not be swayed by short-term economic activity. However, this finding is crucial, as it highlights strategic moments when activists should intensify their efforts. Science plays a troubling role in these interactions. In addition to being influenced by the economic cycle, it appears that the more attention scientific journals devote to climate change, the less attention it receives from the media.

5 Conclusion

We have documented the evolution of mentions of climate change in different environments: policy, science, Economics, and the general public (proxied by news media). We have also proposed a model of how these different environments influence one another and estimated the model's parameters. We find large fluctuations in interest and noteworthy cross-influences. A particularly salient finding is how GDP fluctuations affect interest in climate change. These observations could be a useful tool for activists and other groups interested in strategically influencing social debate.

Future research could expand our results by conducting a more fine-grained analysis of the connections within the different groups, potentially using tools from complex social network analysis. For instance, one could disaggregate the time series of central bankers' speeches and attempt to identify who first brought this issue to the attention of their colleagues and how that influence spread through the network. Alternatively, a larger sample of news media could be analyzed, focusing on both the mentions and their valence (whether climate change is mentioned from a climate-skeptic perspective or as something that needs to be addressed). In this way, one could examine whether negative or positive mentions spread differently, and whether they reinforce or counteract one another.

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Appendix A. Climate Change Vocabulary

Black Carbon Aerosol, Carbon Capture and Sequestration, Carbon Cycle, Carbon Dioxide Equivalent, Carbon Dioxide, Fertilization, Carbon Footprint, Carbon Sequestration, Climate Change, Climate Feedback, Climate Model, Climate Sensitivity, Earth System, Climate System, Coal Mine Methane, Coalbed Methane, Coral Bleaching, Emissions Factor, Energy Efficiency, Feedback Mechanisms, Global Average Temperature, Global Warming, Greenhouse Effect, Earth System, Indirect Emissions, Ocean Acidification, Relative Sea Level Rise, Sea Surface Temperature, Soil Carbon, Sulfate Aerosols, Sulfur Hexafluoride.

Appendix B. Newspapers

Name	Country	Name	Country
Courier Mail	Australia	The Straits Times	Singapore
Daily Telegraph	Australia	ABC	Spain
Herald-Sun	Australia	El Mundo	Spain
The Age	Australia	El País	Spain
The Australian	Australia	Daily Mail	U.K.
The Australian Financial Review	Australia	Daily Star	U.K.
The Sydney Morning Herald	Australia	Daily Star Sunday	U.K.
Calgary Herald	Canada	Financial Times	U.K.
National Post	Canada	i (U.K.)	U.K.
The Globe and Mail	Canada	Sunday Express	U.K.
The Toronto Star	Canada	The Daily Express	U.K.
Vancouver Sun	Canada	The Daily Mirror	U.K.
La Croix	France	The Daily Telegraph	U.K.
Le Figaro	France	The Guardian	U.K.
Les Echos	France	The Independent	U.K.
BILD	Germany	The Mail on Sunday	U.K.
Die Welt	Germany	The Observer	U.K.
DIE ZEIT	Germany	The Sun	U.K.
Deccan Herald (India)	India	The Sunday Mirror	U.K.
Hindustan Times	India	The Sunday Telegraph	U.K.
Indian Express	India	The Sunday Times	U.K.
The Economic Times (India)	India	The Times	U.K.
The Hindu	India	Chicago Tribune	U.S.
The Telegraph (India)	India	New York Daily News	U.S.
The Times of India	India	New York Post	U.S.
The Irish Examiner	Ireland	Star-Tribune	U.S.
Irish Daily Mail	Ireland	Tampa Bay Times	U.S.
Irish Daily Star	Ireland	The Atlanta Journal	U.S.
Irish Independent	Ireland	The Boston Globe	U.S.
The Irish Times	Ireland	The New York Times	U.S.
The Sunday Independent (Ireland)	Ireland	The Philadelphia Inquirer	U.S.
Corriere della Sera	Italy	The Wall Street Journal	U.S.
La Repubblica	Italy	The Washington Post	U.S.
La Stampa	Italy	USA Today	U.S.
Business Times Singapore	Singapore		