Did Climate Scientists "Bend Their Objectivity to Obtain Government Grants"?*

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Abstract

Some scientists and public policy analysts have speculated that U.S. research funding agencies favored grant applicants who promoted, or at least did not speak out against, the threat posed by climate change. This paper investigates this theory empirically, using data from the RAND RaDiUS database of federal research funding, the Oregon Petition and the Journal of Climate. On the whole, the evidence in support of the theory is found to be weak.

Keywords: Climate change, research funding, bias, bureaucracy

*This quote is from "Viewpoint: Get off the warming bandwagon," (BBC News, November 16, 2000) by William M. Gray, a climate scientist at Colorado State University.

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1 Introduction

The degree to which there is scientific agreement on climate change is still a subject of debate. Numerous highly reputable organizations have explicitly used the word "consensus" in official statements or reports in reference to the body of evidence on the subject.[1] One argument for why this term may not be accurate is that scientists have an incentive to promote, or at least not speak out against, the threat of climate change in order to maintain their government funding. William M. Gray, an emeritus professor of atmospheric science at Colorado State University, is a leading proponent of this argument. He authored the quote referred to in the title of this paper in a BBC Op-Ed piece in 2000, and has made similar comments elsewhere since then.[2] Richard S. Lindzen, a professor of atmospheric science at MIT has expressed similar views on the subject, writing, "Scientists who dissent from the alarmism have seen their grant funds disappear."[3]

The theory underlying this claim is that government agencies that provide climate change research grants benefit as the public's perception of the threat posed by climate change becomes more dire. When the public's–and legislators'–fear grows, the agencies in turn are able to increase their budgets and power. Thus, these agencies favor researchers who promote the threat of climate change.[4] Spencer (2005) articulates the idea clearly: "Government agencies that disperse research funds have an infrastructure that depends upon congressional support for their existence. Their level of continued support depends upon the level of the threat perceived by the public, which then justifies the expenditure of tax dollars." It is also argued that climate change is essentially the scientific fashion of the moment, and those who do not conform to the fashion are ostracized from the community. As Gray has said, referring to climate scientists' need to not contradict the apparent consensus, "You've got to go along with the crowd."[5,6]

[1] See, for example, the American Association for the Advancement of Science Board Statement on Climate Change made on December 9, 2006 and "Understanding and Responding to Climate Change," US National Academies of Science, October, 2005.

[2] E.g., "Gore gets a cold shoulder," *Sydney Morning Herald*, October 14, 2007.

[3] "Climate of Fear," *The Wall Street Journal*, April 12, 2006.

[4] This idea is an example of the more general proposition that a bureaucracy's goal is to maximize its budget rather than choose socially optimal policy. The economics of this theory were first developed by Niskanen (1968). Recent papers finding empirical evidence consistent with the theory include Stine (2005) and Kirchgässner and Schneider (2003).

[5] "The Skeptic," *Denver Westword News*, June 29, 2006.

[6] These arguments are clearly distinct from other recent claims that some agencies have received political pressure to suppress or censor research supporting climate change; see, for example, Union of Concerned Scientists (2008). The various claims are not incompatible as the agencies referred to by Spencer et al. are relatively insulated from political

This paper empirically evaluates the implications of the claim described above: that anti-climate change researchers have been discriminated against by government funding agencies. (It is convenient, in an abuse of language, to refer to scientists who produce research that opposes, or speak out against, the threat posed by climate change as 'anti-climate change', and others as 'pro-climate change' and these terms will be used hereafter in this paper.) To my knowledge, this analysis has not been done before. Kueter (2005) broaches the subject, documenting sources of climate change research funding, both government and private, in detail, but does not look at correlations between research substance and funding outcomes. The lack of formal analysis in this area is not surprising, given the inherent difficulties of measurement and identification. First, there is the problem of measuring a researcher's, or study's, perspective on the issue. Second, there is the problem of disentangling this perspective from research quality. This paper uses two methods of analysis to address these difficulties, neither of which relies on *ad hoc* assumptions. In the primary analysis the "Oregon Petition" is used as a natural experiment to look at how National Science Foundation (NSF) grants changed for scientists who signed a major petition opposing the Kyoto Protocol. In a secondary analysis the relationship between climate change related keywords in grant abstracts, and abstracts of papers in the top climate science journal, the Journal of Climate, is examined. In both analyses I use research funding data from the RAND RaDiUS database. All data are described in detail below. I find some evidence in support of the theory of government bias, but in general the evidence is weak or non-robust. There are no strong patterns of discrimination against scientists known to be anti-climate change, or unjustified preferences for funding global warming research. Still, a number of questions are raised for future research, which are discussed throughout this paper.

2 The Grant Data

The grant data source is the RAND RaDiUS database (https://radius.rand.org/radius/index.html) of U.S. federal support for research and development. The database was freely available to the public

pressure, and thus could favor climate change even while other, more politically sensitive agencies do the opposite.

until March, 2008.[7] It had extensive data on all U.S. federal research funding from 1993 to 2006. These data include, among other variables, amount of funding, start year of grant, end year of grant, agency, bureau, program and project. The abstract from the grant proposal is also often available, though its length varies substantially depending on the funding agency. Researcher name is provided for NSF grants, but not for grants from other agencies. Because of this, and because the NSF is one of the primary funders of climate change research, most of the analysis in this paper is based on NSF grant data.

Figure 1 presents a few general trends over the sample time frame. The top graph shows three time series: all NSF grants and grants for the Geosciences (GEO) and Office of Polar Programs (OPP) bureaus.[8] We see that both total and GEO grants increased steadily over time, with the annual number increasing 30% (31% for GEO) from 1993 to 2006. OPP grants also increased steadily, but by a much greater percentage (71%) over the sample period. In other words, GEO grants did not account for a disproportionate fraction of the increase in total grants (around 16% of all NSF grants were in the GEO bureau throughout the period). OPP grants did account for a disproportionate share of the increase, but constitute a much smaller fraction of all NSF grants; OPP grants were 2.1% of the total in 1993 and 2.8% of the total in 2006. Moreover, the total number of grants and GEO grants does not appear to have increased by an inordinately large percentage over time, while the number of OPP grants has. This suggests that OPP, as a bureau, may have had a greater interest in promoting the climate change threat than GEO, as the issue did cause OPP to grow substantially.

The bottom two graphs illustrate changes in climate-specific grants–grants that contained the word "climate" in their abstracts. For both GEO and OPP the totals increased much more sharply over the sample period, by 162% and 369% respectively.[9] These grants are broken out into two groups, those that include the phrase "climate change" in the abstract and those that do not. It is noteworthy that for both the GEO and OPP series the number of climate grants without the phrase climate change

[7]The data used for this study were downloaded in the four months prior to the database becoming unavailable. According to an email from the NSF contact given on the RAND website, the database is currently not available because "plans are underway to transition to an improved database".

[8]I concentrate on GEO and OPP grants in this paper as they account for the vast majority of NSF climate science grants.

[9]Grants from the National Oceanic and Atmospheric Administration (NOAA)–the other major provider of funding for climate research–increased by around 160% over the sample period.

accounted for the bulk of the increase in all climate-grants until around 2002, while the opposite is true after that point. In fact, the number of OPP climate-grants without the phrase climate change actually decreased in the last several years, while those for GEO increased only slightly. This is circumstantial evidence that grant proposals containing this phrase were favored in the last five years, especially for OPP; of course, it does not show that this favoritism was unjustified. It is somewhat suspicious that this particular phrase seemed to be relatively (within the set of climate-grants) increasingly important, especially since the phrase may be associated with those who are pro-climate change. While it is possible that the vernacular in the field simply changed naturally over time, and the grant abstracts reflect this, it is not clear why the changes are relatively different for OPP and GEO grants. These data are merely suggestive, however, and need to be used together with data from other sources to draw more precise inferences, which is done in the following two sections.

[Figure 1]

3 The Oregon Petition

The Petition Project, often referred to as the Oregon Petition, is an ongoing effort to document the opposition of American scientists to the Kyoto Protocol. The project began in April, 1998 when its organizers sent a mailing to tens of thousands of U.S. scientists. The mailing included the petition itself, a cover letter and a copy of Robinson et al. (2007), which was unpublished at the time.[10] The mailing materials and the list of signers are currently available on the project's website (http://www.oism.org/pproject/). The petition requests that the U.S. government "reject the [Kyoto Protocol]," and says "there is no convincing evidence that human release of...greenhouse gases is causing or will, in the foreseeable future, cause catastrophic heating" (see the Appendix for the full text). The project is entirely funded by donations from individuals, and its organizers are scientists primarily associated with the Oregon Institute of Science and Medicine, a small non-profit research organization (http://www.oism.org/).

The petition is controversial for several reasons. First, it is alleged that the mailing appeared as

[10]The paper states in its abstract "that increases [in carbon dioxide] during the 20th and early 21st centuries have produced no deleterious effects upon Earths weather and climate."

if it were officially associated with the National Academy of Sciences (NAS) (Rampton and Stauber (2001)). This is because the Robinson paper was printed in the same format as the official Proceedings of the NAS, and the cover letter was signed by Frederick Seitz as the Academy's "Past President". NAS responded to this by issuing a news release disassociating itself with the petition and the manuscript. Still, most of the signatures were obtained before this statement was made, and it is very possible that some of the signers were misled. A second reason the petition is controversial is that most of the signers do not have Ph.D.'s in areas closely related to climate science. In fact, most of them do not have Ph.D.'s at all, as the only requirement for signing is to have "formal training" or "specialized experience" in "physical science", and the enforcement of even this standard was questionable. Further, the institutions of the signers are not listed on the Petition Project's website, and many of the names do not include a middle initial, making them difficult to verify.

Still, the petition represents a list of scientists who are publicly known–or at least potentially perceived–to be anti-climate change. Therefore, the petition can be treated as a natural experiment. By limiting attention to petition signers with Ph.D.'s, and to grants for climate science research, if petition signers saw decreases in grant outcomes after signing the petition, relative to scientists who did not sign the petition, this would be evidence supporting the theory of government bias. By looking at changes in grant outcomes for individual researchers over time, researcher ability is controlled for (to the extent that this is constant). Testing for this evidence will consist of testing the following hypothesis:

Hypothesis 3.1. *Scientists who signed the Oregon Petition received fewer and/or smaller grants from the NSF in the period after signing than before, relative to scientists who did not sign the petition.*

Note that the hypothesis is not that signing the petition *caused* the scientists to receive fewer grants. It is simply that there is a correlation between signing and relative changes in grants over time. Identifying the underlying causal factor is not necessary for providing evidence that the NSF discriminated against anti-climate change researchers. The decrease in funding could be due to the NSF observing the scientists signing the petition and interpreting this as representative of their views on climate change; alternatively, a correlation between decreased funding and signing could be due to

the petition signers being known by the NSF to be anti-climate change for other reasons. Either way, if petition signers received worse grant outcomes after signing controlling for other factors it would be evidence that the NSF was biased against anti-climate change scientists. On the other hand, if signers were thought to be anti-climate change and discriminated against before signing the petition, tests of this hypothesis may be confounded. This issue will be kept in mind and discussed as we proceed.

To test Hypothesis 3.1, I construct a panel data set in which the unit of observation is a researcher-year and the main variables of interest are number of grants, amount of funding, and whether or not the researcher has signed the petition at the time of the observation. Given the NSF grant data available, the primary challenge involved in creating this dataset is determining which researchers were in fact petition signers, i.e. matching the grant and petition data. The petition data were obtained from the project's website in January and February of 2008, when there were approximately 17,000 signatures.[11] Because the petition includes so many names there are undoubtedly many in both the petition and grant data that do not correspond to the same person. Moreover, there may be names that do in fact correspond to the same person, but take different forms in the two data sources. For example, the entire middle name is sometimes provided in the petition but rarely given in the grant data. Consequently, the names cannot be matched blithely. I use the following criteria for matching names, or classifying researchers as signers: 1) either the first name, middle initial and last name are the same in both the petition and grant data, *or* both the first and last name are the same, and no middle initial is provided, in both the petition and grant data; and 2) the name is associated with a degree of Ph.D. in the petition.[12] The grant data are limited to NSF GEO and OPP grants, to ensure that the grants are related to climate science. These criteria are fairly restrictive, and thus limit the number of false positives (grant recipients falsely classified as signers), while being sufficiently broad to yield a substantial number of signers. One issue to be aware of with this method is that all petition

[11]The vast majority of these signatures were obtained in the two years following the mailing (Rampton and Stauber (2001)). The website was revised in May of 2008 and now claims to have 31,000 signatures, implying that over 10,000 were added in recent months. These new additions are intentionally excluded from this analysis, as they would not be associated with changes in government grants over the sample period (pre-2007) if their climate change views only became public in the last two years. However, it appears that some information for previous signers was revised, such as middle initials added; this new information was incorporated in the data used in this paper.

[12]Researchers whose first and last names are the same and have a middle initial in either the petition or grant data (but not both) are dropped from the sample, as it is unlikely that they are signers, but some may be (there are less than 15 of these cases). Rudolph J. Dichtl is classified as a signer although he does not list a degree of Ph.D. in the petition as the name appears to be sufficiently distinctive such that is unlikely to correspond to more than one person.

signers who never received a grant are ignored. So if signing prevented any of these scientists from *ever* receiving a grant this effect will not be captured in this analysis. This is necessary because there is no control group for these signers (scientists who did not sign the petition and received zero grants in the sample period are also excluded from the data sets).

[Table 1]

Table 1 presents summary statistics for the constructed sample.[13] There were 40 researchers who received at least one new GEO or OPP grant from 1993-2006 who are classified as signers. These data alleviate the concern that signers may have been discriminated due to NSF bias prior to signing the petition, as they received more grants per year than non-signers in the 1993-1999 period. Interestingly, grants did decrease for signers after 1999 (both absolutely, and relative to the non-signers). These differences may be not be due to NSF bias though if there are other variables correlated with both petition signing and grants outcomes. The most likely candidate for this type of variable is researcher ability, or productivity–it is possible that researchers' productivities changed over time in different ways for signers and non-signers. This would confound the estimated effect of signing on grants received, since productivity is clearly correlated with grant outcomes. One reason productivity might change is age. Although age is not observed directly in the data, it can be accounted for indirectly via the year in which a researcher received her/his first grant. Let $FstYr_i$ denote this variable for researcher i; it will clearly (in expectation) be higher for younger researchers. Thus, it can be used to proxy year of birth. One way to use $FstYr$ to account for age is to simply limit the sample to researchers whose $FstYr$ is below a cut-off year; another is to use $Year_t - FstYr_i$ to roughly approximate age in period t for researcher i. I use both of these methods, and refer to the latter approximation as $\widetilde{Age}_{it}$.

It appears that age is indeed correlated with signing: the means of $FstYr$ for signers and non-signers are 1994.9 and 1996.9, i.e. the signers are on average older than non-signers. Internet searches for the years in which signers received their bachelors degrees confirmed this finding as the average for this group is 1969.1, implying that their mean age was over 50 in the year 2000.[14] Thus, $FstYr$

[13] Amount of funding is deflated using the CPI 1982-1984 index and researchers who received at least $1,000,000 in funding for any single year are dropped, as no signer ever received this much, and researchers who received 0 new grants from 1993 forward are dropped.

[14] Year of bachelors was only found for 30 of the signers; the year of Ph.D. and starting year of work were found for two other signers (1951 and 1962). One reason these data may have been difficult to find online is that some of the signers have already retired, which would of course cause the sample mean year of bachelors to be biased upward.

does appear to be positively correlated with year of birth. Figure 2 depicts the average number of new grants per year received by FL signers and non-signers, separately for all researchers and just those whose $FstYr$ is less than 1998. The importance of controlling for $FstYr$ is clear; when this is ignored the signers' grants are trending down over time while those of non-signers are approximately constant. When $FstYr$ is controlled for both groups' average grants trend down at approximately the same rate. The signers' mean $FstYr$ is partly low because most signers signed in 1998, and thus must have had their degrees by then, whereas this is not true for non-signers. However, even when this is accounted for by limiting the data to those who received their first grant before 1998 the mean $FstYr$ for signers is low; the means then are 1992.2 and 1992.8 for signers and non-signers, respectively. $FstYr$ would also be biased downward for signers if some of them were prevented from ever receiving a grant as a result of signing the petition; other reasons the signers are older on average are discussed further at the end of this section.

[Figure 2]

Now that the primary potentially confounding variable has been accounted for, I formally test Hypothesis 3.1 using variants of the following linear model:

$$Y_{it} = \beta Petition_{it} + \gamma_1 \widetilde{Age}_{it} + \gamma_2 \widetilde{Age}_{it}^{\,2} + \alpha_i + \delta_t + \epsilon_{it}. \tag{1}$$

Y denotes a generic grant outcome variable. $Petition$ is an indicator variable equal to one if researcher i has signed the petition in period t. A quadratic is used for $\widetilde{Age}_{it}$ to allow for non-linear effects; results are similar when higher order polynomials are used. α and δ are researcher and time fixed effects. β is the estimate of interest; testing Hypothesis 3.1 is equivalent to testing $\beta < 0$. The key assumption for the validity of this test is that conditional on $\widetilde{Age}_{it}$ and the fixed effects, signing is independent of other factors that affect Y.

I use linear and Poisson[15] models to estimate (1) in which Y is number of grants per year ($Grants$), a Tobit model for Y of total amount of funding per year ($TotAmt$), and an OLS model for Y of average

[15] In the Poisson models I used an indicator variable for $t > 1999$ because the maximum likelihood routine did not converge for the model with yearly fixed effects.

funding per grant ($AvgAmt$).[16] I also estimate separate models for all grants and just grants with the term 'climate' in the grant abstract.[17] I assume that $Petition_{it}$ is equal to one if i is a 'signer' and $t \geq 2000$, otherwise $Petition_{it} = 0$. Results are similar for different cut-off years.

[Table 2]

Table 2 presents estimation results for both the full sample, and a sample limited to researchers who received their first grant prior to 1998.[18] Estimates for the control variable coefficients are omitted for brevity. The $Grants$ estimates are all insignificant; they are very close to 0 for the restricted sample and actually positive for 'climate' grants. The full sample, 'all grants' $TotAmt$ estimate is significant at the 10% level, but this result is not robust to dropping researchers with late $FstYr$'s. The full sample estimate also becomes insignificant when Richard S. Lindzen, who was referred to in the introduction of this paper and experienced declines in grant outcomes after 1999, is dropped, though the p-value is still low (0.153). None of the $AvgAmt$ estimates are significant, though the 'climate' estimates are close, and are robust to controlling for age by dropping late $FstYr$'s. The p-values for these estimates remain low (less than 0.2) even after dropping Lindzen and William M. Gray, who was also mentioned in the introduction and experienced a decline in grant sizes over time. Thus, these results provide some evidence that average grant sizes decreased for signers, but the evidence is weak as the estimates are not significant at conventional levels. There is very little evidence that signers received fewer grants after signing.

One reason the estimates might be biased towards zero would be if researchers known to be anti-climate change simply did not sign the petition. In this case, they would essentially be misclassified as non-signers, and the magnitude of β would be under-estimated. I investigate this informally by inspecting the researchers whose names are not in the petition, who experienced the greatest decreases in number of grants from 1993-1999 to 2000-2006.[19] None of these researchers appear to be well-known climate skeptics, and they do appear to be relatively senior on average, as at least half received their

[16] Fixed effects are unavailable for Tobit, and the panel is very unbalanced for the $AvgAmt$ model, so an indicator for 'signer' is used in all periods for these specifications in place of fixed effects.

[17] In the 'climate' analysis the data are limited to researchers who received at least one 'climate' grant from 1993-2006.

[18] There are 29 signers who satisfy this criterion.

[19] These are the 12 non-signers who obtained eight or more total grants in the 1993-1999 period than the 2000-2006 period.

Ph.D.'s before 1970.[20]

I also take a closer look at the three signers who received OPP grants, James F. Drake, Rudolph J. Dichtl and Vinod K. Saxena. These researchers are worthy of further examination as the graphs in Section 2 indicated that bias might have been a more significant issue in this bureau, and their mean number of grants was substantially lower in the later time period. Drake is a physicist who received only one grant in the sample period (1997). Dichtl received exactly one grant before (1997) and one after (2004) signing. Saxena, while not a well known skeptic has been quoted speaking out against Kyoto,[21] however, he also received only one OPP grant in the sample period (1993), and so did not experience a substantial decrease in grants. While the sample size is very small for this group, there are no clear signs that they received unfair treatment after signing.

In summary, this exercise has shown that there are substantial unconditional differences in differences in grants received for signers and non-signers, pre and post-2000. This may be partly why the suspicions about the agendas of government agencies described in the introduction arose. But, when age is accounted for the differences in number of grants become statistically no different from noise, and often have a sign that is inconsistent with the theory of NSF discrimination. Age also seems to explain differences in average grant sizes, though the results here are mixed.

The finding that age explains differences in number of grants is important, but its interpretation depends on the reason for which signers were older on average. If the age of signers was endogenous, i.e. signers were older for reasons related to the issue of government bias, the econometric estimates could be less meaningful. For instance, if younger scientists *knew* that they would be punished for signing, and older scientists *knew* they would not be, perhaps because their reputations were sufficiently strong, the data would be completely consistent with the existence of NSF bias. On the other hand, if younger scientists simply feared they would be punished for signing, and older scientists were less concerned about this effect because of their age, the data would show that the younger scientists' fears were largely unfounded. And if signers were older for reasons unrelated to government bias, e.g., older scientists were more skeptical of the climate models that were popular in the 90's, then

[20] Leroy M. Dorman, Alan Zindler, Harry W. Green, Philip G. Richards, Richard E. Hallgren and Robert S. Coe.
[21] http://www.spaceref.com/news/viewpr.html?pid=3918

again $\hat{\beta} \approx 0$ would be strong evidence against NSF bias. Thus, the question of why signers were older on average, which is beyond the scope of this paper, is crucial to interpreting the empirical findings discussed above. Regardless, the data at least do not provide robust support for rejecting the null of no government bias.

4 Journal of Climate

To complement the Oregon Petition analysis, the relationship between grants and climate change research in the Journal of Climate is also examined. The Journal of Climate is published by the American Meteorological Society, is not widely thought of as having any ideological biases, and is considered to be one of the top climate science journals, if not the premier journal in the field. It has been published since 1988 and recent annual volumes have consisted of approximately 6,000 pages. Two types of data were collected from each article in the first 12 issues of the 1998, 2001, 2004 and 2007 volumes of the journal (a total of 674 articles): 1) the NSF and NOAA grant numbers from the 'Acknowledgments' section, when these types of grants were listed as providing support, and 2) climate change related keywords in the abstracts and titles.[22] The grant numbers may clearly be useful in combination with the RAND data; the abstract/title keywords are used simply to indicate that the subject of an article relates to climate change. I do not attempt to determine explicitly whether a paper is pro or anti-climate change, both because this is inherently subjective, and due to my lack of expertise in climate science. For simplicity the set of keywords is limited to "climate change", "carbon", "CO2" and "greenhouse". The data collection is limited to keywords in the abstract and title because this allows for greater differentiation of the articles (a large fraction of articles contain at least one keyword in the body text).

Of NSF funded articles,[23] 12.8% had at least one climate change keyword in the abstract, as compared to 15.6% of non-NSF funded papers. Only 5.6% of NOAA funded articles had a keyword as

[22]The NOAA data are collected in addition to the NSF data as the names of the grant recipients are not necessary for the analysis discussed in this section. Unfortunately the NOAA grant abstracts are on average very short, which limits their usefulness for the tests soon to be discussed.

[23]These are defined as articles that listed at least one NSF grant number in their acknowledgments (some papers acknowledged support from the agency without stating a specific grant number). NOAA funded articles are defined analogously.

compared to 16.5% of non-NOAA funded articles. These numbers indicate that NSF and NOAA funded articles were actually relatively *unlikely* to be about climate change, but because the vast majority of other Journal of Climate (hereafter JoC) articles were also supported by government grants, either US or foreign, this finding is difficult to interpret. Since both NSF/NOAA and non-NSF/NOAA funded papers were supported by government agencies, we would not hypothesize there to be any difference between the two groups of articles even if there was funding bias. To draw any insight into the question of government bias the data thus needs to be examined in different ways.

I first examine the relative frequencies with which different types of grants led to papers published in the JoC. Grants are grouped by those with keywords in their grant abstracts and those without, and I compare the respective frequencies with which these two groups yielded JoC papers. The idea is that if the agencies were biased in favor of grant proposals containing keywords then research funded by these grants would on average be of lower quality than other research. Thus this research would be less likely to be published in the JoC. More formally, letting α_K (α_{NK}) denote the fraction of grants with (without) keywords in their abstracts that led to papers published in the JoC, $\alpha_K < \alpha_{NK}$ would be evidence of funding bias. This is an easily testable hypothesis.[24] The validity of this test relies on the assumptions already stated about the JoC's above average quality and lack of bias on the climate change issue. Validity also rests on the assumption that there are not factors other than bias that would cause grants with keywords to be more or less likely to yield JoC papers than grants without keywords. To account for this, I need to be sure that I only use data on grants intended for climate science research; I thus limit the grant data to atmospheric sciences (ATM) (a subset of GEO grants) and OPP grants from 1996-2005.[25]

Table 3 reports these frequencies and the test results. The null hypothesis of no government bias is not rejected at any reasonable significance level for any grant type.[26] In fact, grants with keywords in the abstract were actually *more* likely to lead to research that would be published in the JoC than other grants, for all grant types (ATM, OPP and NOAA). This is likely because these keywords

[24]Note that this test only involves keywords in the grant abstracts, and not the JoC article abstracts.

[25]The vast majority of JoC papers supported by NSF grants referred to one of these two types of grants. All GEO grants are used for the Oregon Petition analysis to improve sample size and because the 'climate' keyword is used to restrict subjects; results are similar using only ATM grants.

[26]The NOAA p-value is relatively low because of the small number of grants with keywords in their abstracts, which is a result of the grants abstracts being very short.

indicate that the research is relatively suitable for the JoC; still, these results show that the agencies did not unduly favor climate change research grant proposals. On the contrary, the data imply that climate change grants are associated with relatively high quality research.

Finally, I look at the relative frequencies of keywords in JoC versus grant abstracts. It may not be meaningful to compare these directly as the abstracts are of different lengths and exogenously different language types. One way to control for these differences is by making a comparison within the set of JoC papers. The question then is how to do this in a meaningful way. As mentioned above, comparing NSF funded to non NSF funded JoC papers is not that helpful. The next option is to compare within the subset of JoC papers that are NSF funded. This subset can be divided into those with keywords in the grant abstract, and those without.[27] We can then compare the fractions that yielded JoC articles *with climate change keywords* across groups. Here, the idea is that if the NSF was biased then there may not be a tight relationship between keywords in JoC papers and keywords in the corresponding grants. Researchers may have used keywords in their grant abstracts just to obtain the grants, and not really to conduct climate change research. If this were the case, then we would see little correlation between keywords in grant abstracts and the corresponding JoC article abstracts.

To test this idea now let $\widetilde{\alpha}_K$ ($\widetilde{\alpha}_{NK}$) denote the fraction of JoC papers funded by NSF grants with keywords (NSF grants with no keywords) that have keywords in their JoC abstracts. For this test it is convenient to make the null hypothesis that of government bias: $\widetilde{\alpha}_K = \widetilde{\alpha}_{NK}$. In other words, the null is that a keyword being in a grant abstract has no effect on the likelihood that the grant led to climate change-related research in the JoC. The alternative is what we would expect with no bias, $\widetilde{\alpha}_K > \widetilde{\alpha}_{NK}$. Table 3 reports the results from these tests. While we can reject the null at the 1% level for ATM grants, we cannot do the same for OPP grants. $\widetilde{\alpha}_K > \widetilde{\alpha}_{NK}$ for these grants, but not significantly so, and while this is partly due to smaller sample size, the $\widetilde{\alpha}_K$ and $\widetilde{\alpha}_{NK}$ numbers are suspiciously close. This is evidence that OPP grant proposals containing climate change keywords were unduly favored, while ATM ones were not.

[Table 3]

In summary, these tests are somewhat less precise than those involving the Oregon Petition data,

[27] The NOAA data can not be used for this comparison because of their limited abstracts.

but they are complementary in that they are free from the controversy associated with the petition and also make some use of grant data from another agency, the NOAA. Overall, the results show no evidence that GEO-ATM grants were given for biased reasons, but mixed evidence that OPP ones were. This is consistent with the data shown in Figure 1, indicating that the OPP bureau grew much more rapidly during the sample period and had a relatively large amount to gain from the prominence of the climate change issue.

5 Concluding Remarks

The primary findings from this work are that researchers associated with opposition to the Kyoto Protocol (Oregon Petition signers) did receive fewer grants after 1999 as compared to researchers who did not sign the petition, but when age is accounted for these differences are not statistically significant. There is some evidence that average grant size for signers declined after 1999, but it is not robust. NSF and NOAA grants with climate change related terms in their abstracts were more likely to yield high quality climate science research than grants that did not include these terms. But, the Office of Polar Programs may have unduly favored grant proposals containing these terms, as they were not statistically more likely to lead to Journal of Climate articles on climate change than grants without climate change terms in their abstracts.

These findings explain, to some extent, why there was suspicion about the agendas of government funding agencies, and also should assuage most of our fears. Still, the issue is not resolved. One especially important question arising from this work is why petition signers were older on average than non-signers. If this phenomenon was related to government bias, then the Oregon Petition tests could lose a great deal of their power. Moreover, the lack of NOAA data is unsatisfying, as is the limited NSF-OPP data, and the possibility that there were researchers who never received grants due to government bias also can not be ruled out. Most likely richer data, perhaps including characteristics of rejected OPP grant proposals or NOAA researcher names, would be necessary to conduct more powerful tests than those discussed in this paper.

A Petition Project Text (as of February 2008)

Preamble: Thank you for your interest in signing this petition, which has now been signed by more than 20,000 American scientists. Signatories to the petition are required to have formal training or specialized experience in the analysis of information in physical science. This includes many of those with BS, MS, or PhD degrees in science, engineering, and related disciplines. If you think you may qualify, please sign and give your reasons for thinking so. We carefully review the signed petitions when they arrive and make certain that the retained signatories are appropriate.

Petition: We urge the United States government to reject the global warming agreement that was written in Kyoto, Japan in December, 1997, and any other similar proposals. The proposed limits on greenhouse gases would harm the environment, hinder the advance of science and technology, and damage the health and welfare of mankind.

There is no convincing scientific evidence that human release of carbon dioxide, methane, or other greenhouse gases is causing or will, in the foreseeable future, cause catastrophic heating of the Earth's atmosphere and disruption of the Earth's climate. Moreover, there is substantial scientific evidence that increases in atmospheric carbon dioxide produce many beneficial effects upon the natural plant and animal environments of the Earth.

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Table 1: Descriptive Statistics: Oregon Petition-NSF Grants Matched Data (Standard *Deviations* in Parentheses)

		# Grants/Yr		$ Total (000s)/Yr		$ (000s)/Grant		N
		1993-1999	2000-2006	1993-1999	2000-2006	1993-1999	2000-2006	
Signers	GEO	0.223	0.161	20.833	15.130	89.692	94.989	39
		(0.459)	(0.424)	(65.911)	(48.809)	(88.309)	(72.741)	
	OPP	0.143	0.048	38.812	7.763	271.687	163.018	3
		(0.359)	(0.218)	(142.825)	(35.573)	(330.283)	(.)	
	Total	0.229	0.161	23.223	15.334	98.946	96.734	40
		(0.461)	(0.422)	(75.461)	(49.050)	(113.061)	(72.600)	
Non-Signers	GEO	0.191	0.213	17.112	21.785	90.793	104.073	6214
		(0.458)	(0.485)	(56.500)	(67.760)	(87.989)	(102.702)	
	OPP	0.158	0.177	15.879	19.299	101.495	109.923	1264
		(0.422)	(0.433)	(58.141)	(67.854)	(100.589)	(113.619)	
	Total	0.200	0.223	18.227	23.038	92.307	104.797	6935
		(0.475)	(0.501)	(59.458)	(70.999)	(90.175)	(104.333)	

Table 2: Estimation Results

		Grants		*TotAmt*	*AvgAmt*
	$\hat{\beta}$	Linear (FE)	Poisson (FE)	Tobit	OLS
Full Sample	All grants (GEO, OPP)	-0.036	-0.266	-41.464†	-14.709
		(0.034)	(0.207)	(24.132)	(19.092)
	'Climate' grants	0.013	0.197	-30.700	-61.789
		(0.085)	(0.371)	(69.257)	(39.367)
$FstYr < 1998$	All grants (GEO, OPP)	-0.001	-0.125	-26.342	-17.542
		(0.044)	(0.212)	(26.644)	(19.619)
	'Climate' grants	0.029	0.188	-13.098	-60.567
		(0.091)	(0.367)	(72.632)	(40.077)

Significance levels : $\dagger$: 10% $*$: 5% $**$: 1%

Standard errors in parentheses. Robust standard errors clustered by researcher used for all models except Poisson.

Table 3: Journal of Climate (JoC) T-Tests

	Keyword in Grant Abstract $(\alpha_K, \widetilde{\alpha}_K)$	No Keyword in Grant Abstract $(\alpha_{NK}, \widetilde{\alpha}_{NK})$	N	p-value $(H_a : \alpha_K < \alpha_{NK}, H_a : \widetilde{\alpha}_K > \widetilde{\alpha}_{NK})$
JoC Publication Frequencies (of all grants)				
NSF ATM	0.039	0.020	3,467	99.7%
NSF OPP	0.016	0.008	2,391	96.0%
NOAA	0.019	0.009	5,622	85.2%
JoC Climate Change Keyword Frequencies (of grant-funded JoC papers)				
NSF ATM	0.357	0.075	108	0.0%
NSF OPP	0.188	0.125	32	32.0%

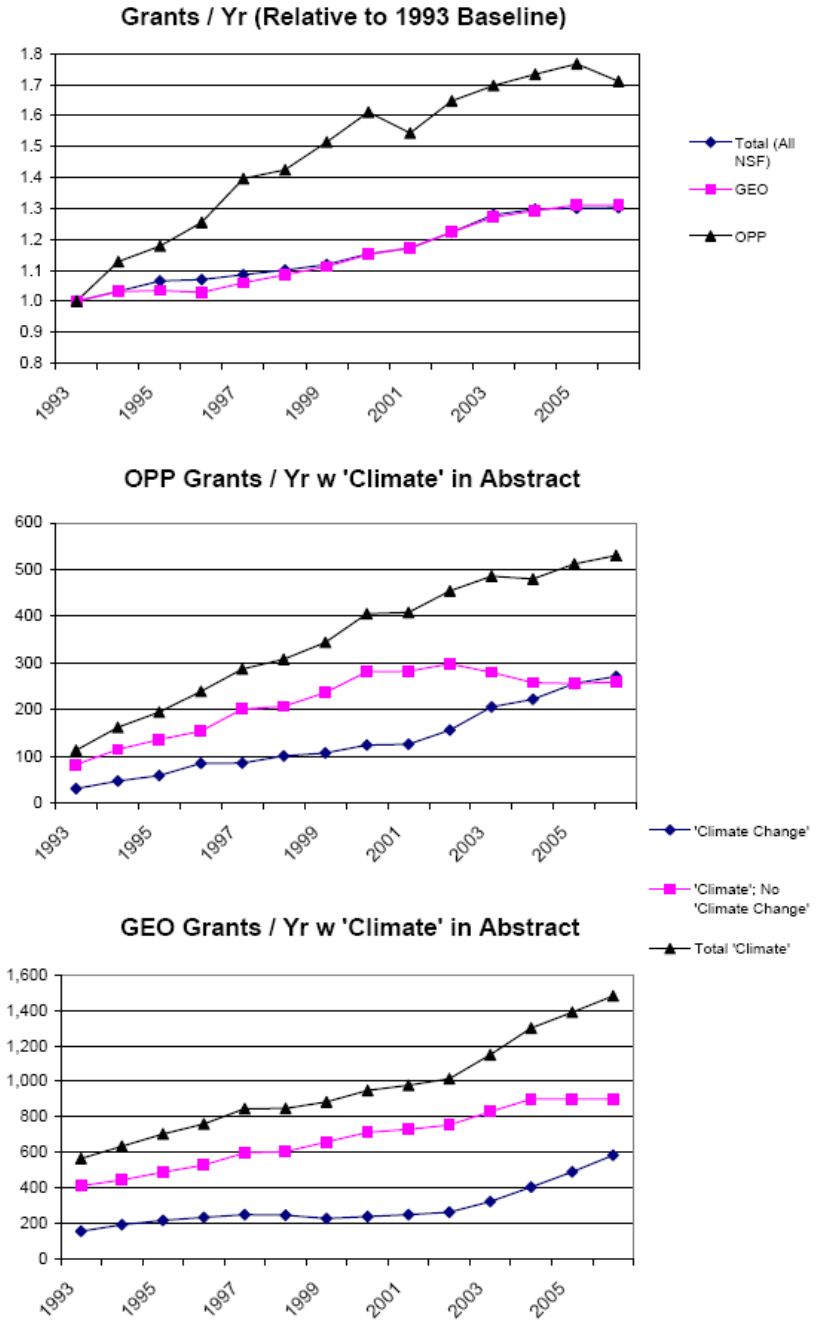

Figure 1: NSF Grants / Year

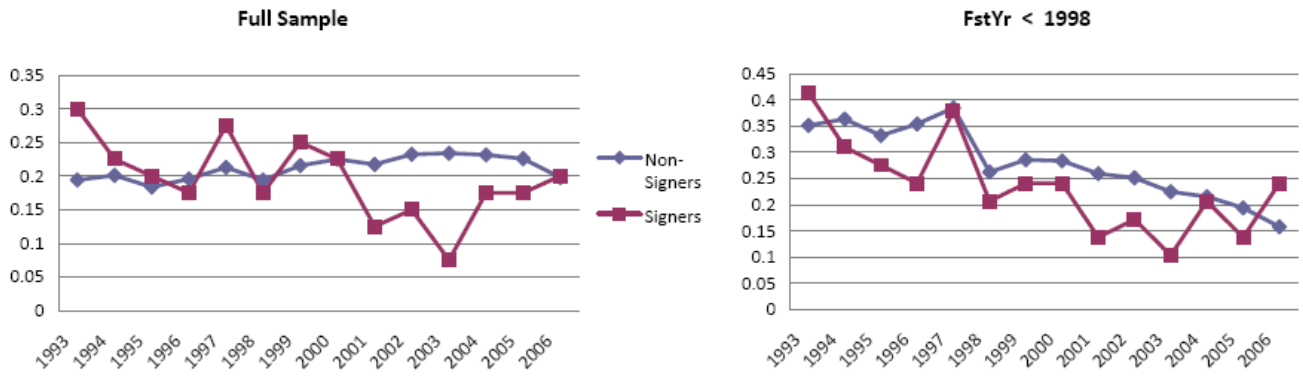

Figure 2: Mean New GEO-OPP Grants / Year