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Climate news articles lack basic climate science

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Abstract

Although climate change is arguably the most urgent issue of our time, the general public knows little about climate science. Here, we investigate how often five basic climate facts are conveyed in *The New York Times* news articles covering climate change from 1980 to 2018. With only one exception, the frequencies with which these facts appear in news articles today are vanishingly small. This suggests that print journalism is a largely untapped resource for educating the public on basic climate facts.

1. Introduction

Where science and public policy overlap, it is important that the public knows the basic scientific facts, as that allows the citizenry to gauge the importance of the issue and to choose the appropriate response. With regards to the issue of global warming, people need to know whether the problem is occurring (fact 1: it is), what is causing it (fact 2: fossil fuels and the greenhouse effect), and whether there is a scientific consensus (fact 3: there is). They also need to know something about the magnitude of the problem (fact 4: massive alteration of our atmosphere) and the timescale of the resulting harm (fact 5: effectively permanent).

Unfortunately, only a small minority of Americans know more than one of these basic facts. The best-known fact is that global warming is happening now (fact 1), which 69% of Americans accept [1]. But, only 12% of Americans know that the mechanism of global warming (fact 2) has something to do with atmospheric gases trapping heat [2]. In fact, many studies have documented the public's inability to identify the burning of fossil fuels and the resulting emissions of carbon dioxide as the primary cause of global warming [3–8]. Perhaps even more striking, only half of Americans think that scientists largely agree that global warming is happening [1]. And only 17% of Americans think that 90+% of climate scientists are in agreement that global warming is happening and is caused by humans [1]. In reality, nearly all—if not all—climate scientists agree on this fact (fact 3). Since knowledge of basic climate science correlates positively with concern about climate change [9–11], the inaction on this issue can be traced, at least in part, to the public's lack of understanding of the basic facts.

Once their formal education is completed, adults receive much of their knowledge about climate science from newspapers [5, 12, 13]. Unfortunately, among newspaper articles covering science topics, less than 10% of the articles' text is devoted to defining scientific terms or giving scientific explanations [14]. As a result, focus groups show that readers crave more contextual facts in the science news articles that they read [15]. Not only does the addition of basic facts aid the readers' comprehension, but it increases the readers' acceptance of the science [16]. Unfortunately, newspaper coverage of science topics often omits the required context, hampering the reader's understanding [17, 18]. This has been argued to be particularly true for newspaper coverage of climate science [19].

Previous research on newspapers' climate coverage has studied the treatment of scientific uncertainty [20] and risk [21], quantified who is quoted in the articles [22] and the frequency of false balance [23], and analyzed in qualitative ways the content of those articles [19, 24–26]. To the best of the authors' knowledge, however, no previous study has performed a quantitative analysis of the frequency of appropriate context—in the form of basic climate-science facts—within newspaper articles covering climate change.

Box 1. The five facts searched for within *The New York Times* articles. Parentheses denote alternate or optional possible wordings.

Warming Now: Global warming is happening now.
Mechanism: 1. Burning fossil fuels (coal, oil, gas) produces greenhouse gases (carbon dioxide), 2. greenhouse gases (carbon dioxide) trap heat, and 3. that trapping of heat causes global warming.
Consensus: The vast majority (90+%, consensus) of climate scientists agree that global warming is happening and is caused by human activity.
Highest CO_2: (Due to the burning of fossil fuels,) there is now more carbon dioxide in the atmosphere than there has been for hundreds of thousands (likely millions) of years.
Permanent: Global warming is permanent (for thousands of years).

In this study, we test for the prevalence of five facts within *The New York Times* (NYT) news articles covering climate change from 1980 to 2018. The NYT is chosen for this study because of its reputation as the nation's paper of record [27] and for its excellence in reporting on environmental issues [24], allowing our results to place something of an upper bound on the quality of newspaper climate coverage in general. The NYT is also a natural choice because of the long list of studies of that have focused on the NYT in their research of climate reporting [17–26, 28].

2. The facts

The five facts for which we search are given in Box 1. Stated succinctly, they are: 1. global warming is happening now, 2. the mechanism of global warming, 3. the scientific consensus, 4. highest CO_2 concentrations in hundreds of thousands or millions of years, and 5. the permanence of global warming.

2.1. Warming now

We know from thermometer records that Earth's average surface temperature has increased 1 °C (2 °F) during the 20th century [29]. This warming is corroborated by many other lines of evidence, including satellite temperature measurements [30] and the shrinking of glaciers throughout the world [31].

2.2. Mechanism

Global warming is an enhancement of Earth's natural greenhouse effect, which was discovered nearly two centuries ago [32]. The mechanism of global warming—whereby the burning of fossil fuel increases carbon dioxide concentrations, leading to an additional trapping of heat and, therefore, warming of the planet—was understood in broad outline by the late 1800s [33] and is understood in exquisite detail today [34]. The reason we focus here on carbon dioxide is that the other greenhouse gases contribute a much smaller warming (altogether, about half as much as CO_2) and, with the exception of some halocarbons, they last in the atmosphere for a much shorter time [34]. For example, methane, whose radiative forcing is equal to about one quarter that of carbon dioxide [35], has a lifetime of only ten years. Carbon dioxide, on the other hand has an effective lifetime measured in tens of thousands of years (see below).

2.3. Consensus

Climate scientists agree that the Earth is warming and that this warming is caused by human emissions of greenhouse gases [36]. Among the studies that have quantified this consensus, it is found that about 97% of climate scientists agree on the existence of global warming and its anthropogenic cause [37–40].

2.4. Highest CO_2

At the time of writing, the atmosphere's concentration of carbon dioxide is 410 ppm and rising at about 2.5 ppm per year. This is higher than any concentration seen on Earth for millions of years [41]. In 1980, when our NYT database begins, the concentration hit 340ppm, which was unambiguously higher than any concentration of CO_2 from the past 800,000 years [42] and at or exceeding the maximum value ever experienced on Earth for millions of years [41]. The human species originated roughly 300,000 years ago [43], so the concentration of carbon dioxide has been higher than ever before in the history of our species during the full time period covered by the NYT database.

2.5. Permanent

Once put into the atmosphere, carbon-cycle models predict that the concentration of carbon dioxide is brought back to its original value by silicate weathering on a timescale of ~100 thousand years [44], which is the same

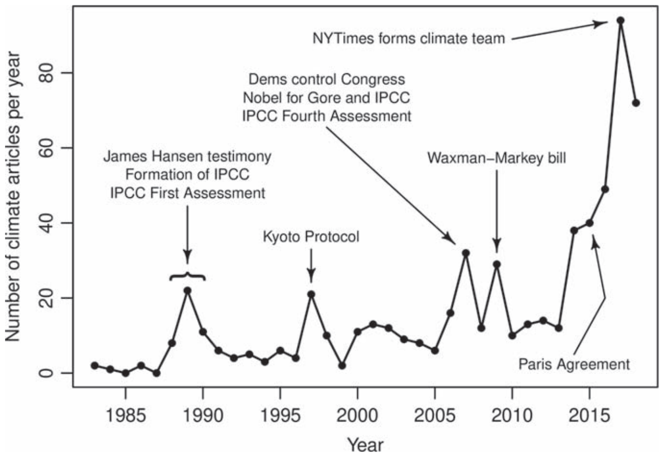

Figure 1. Time series of the 597 *New York Times* climate-change news articles.

length of time that it took Earth to recover from an analogous release of carbon dioxide at the end of the Paleocene [45, 46]. Human agriculture and human civilization originated roughly 10,000 years ago [47], so global warming is effectively permanent on the timescale of human civilization.

3. Analysis

For this study, we used the ProQuest US Major Dailies database, which contains all NYT articles from 1980 up to the present. We identified all NYT articles containing either 'global warming', 'climate change', or 'greenhouse effect' in the title from 1980 to 2018, inclusive. This generated 1801 articles. We subsetted these to standard news articles (excluding, e.g., all op-eds, letters to the editor, editorials, blog posts, newsletters, advertisements, etc.) that have full searchable text and a word count greater than or equal to 500. Duplicate articles were identified using approximate string matching on the full text (appendix B) and the article with the largest word count was kept, while the others were discarded. For duplicate articles from the past two decades, the article with the largest word count is typically the online version. This left us with 597 articles that were distributed in time as shown in figure 1. Although the ProQuest database begins in 1980, the first article that met our criteria was in 1983, so we begin the time series then.

The coverage of climate change has waxed and waned over the years, with peaks in coverage coinciding with well-known events. The first peak occurred during 1988-1990, which coincided with James Hansen's testimony to Congress in 1988, the formation of the Intergovernmental Panel on Climate Change (IPCC) in that same year, and the release of the IPCC First Assessment report in 1990. Coverage peaked again in 1997, coincident with the United Nations Conference of the Parties in Kyoto, Japan, at which parties agreed to the Kyoto Protocol. Coverage peaked again in 2007 when the Democratic Party took control of both houses of Congress, the Nobel Peace Prize was awarded jointly to Albert Gore and the IPCC, and the IPCC released its Fourth Assessment report. In 2009, the American Clean Energy and Security Act, commonly referred to as the Waxman-Markey Bill, was passed by the House of Representatives and would have, if it had been approved by the Senate and signed by the President, established a cap-and-trade system for carbon-dioxide emissions. Finally, in recent years, coverage has spiked with the negotiation of the Paris Agreement (2015) and the establishment of a dedicated climate team at the New York Times (2017) [48].

With hundreds of person-hours contributed by undergraduate researchers, we identified the keywords or character strings without which it was impossible for a paragraph to convey each corresponding fact (appendix C). For each fact, a computer algorithm screened for the paragraphs containing that fact's required character strings, and the first author then read those paragraphs and judged whether the fact was present. Table 1 lists some examples of articles that tested positive for each of the facts. For this table, four articles were drawn randomly (without replacement) to represent each fact (except for the Permanent fact, for which there were only two articles). For each of the randomly selected articles, the ProQuest identification number is given along with the snippet of text that conveyed the relevant fact.

Figure 2 shows the fraction of articles that contain each fact in each year, drawn as black circles. On the abscissa, the tick marks denote January 1 of the corresponding year, while the circles (corresponding to articles over the subsequent twelve months) are positioned at the middle of the corresponding year (i.e. at July 1). For

Table 1. Examples of occurrences of facts in *New York Times* climate-change news articles. (left column) The fact, (middle column) the ProQuest identification number, and (right column) the relevant snippet of text.

Warming Now	432916326	The report... found that rising temperatures had already eroded glaciers, sea ice and permafrost.
	1868157563	[O]lder dams may not be designed to deal with the severe weather patterns California has experienced because of global warming.
	1983944177	The Arctic is not as cold as it used to be—the region is warming faster than any other... Despite an undeniable overall year-round warming trend...
	1975965260	Based on how much the world has warmed... [R]ising carbon dioxide has warmed the planet.
Mech. part 1: Coal, oil, gas	426896230	Burning of fossil fuels accounts for most of the carbon dioxide released worldwide.
→	430369370	...greenhouse gases emitted by the burning of fossil fuel.
GHG / CO_2	432637729	...emissions of carbon dioxide and other greenhouse gases in the burning of fossil fuels.
	1619268739	[T]hey must restrict emissions from additional fossil-fuel burning to about 1 trillion tons of carbon dioxide.
Mech. part 2: GHG / CO_2	2126756961	[M]ethane, a powerful planet-warming greenhouse gas... is more than 25 times as potent as carbon dioxide in trapping heat in the atmosphere.
→	428352355	...heat-trapping gases like carbon dioxide...
Trap heat	431481503	...carbon dioxide and other heat-trapping 'greenhouse gases'...
	425686418	[A]tmospheric carbon dioxide retains heat.
Mech. part 3: Trap heat	430823211	...combat the growth of global warming by limiting the emissions of carbon dioxide and other gases that trap heat...
→ Warmer	427062969	Carbon dioxide from such combustion is believed to be trapping radiation from the Sun and causing Earth to warm.
	428208584	...carbon dioxide, the principal man-made atmospheric gas among several that trap heat... [T]he average global temperature was likely to rise... if emissions of greenhouse gases continue unabated.
	432109543	[T]he report... blames human actions for recent global warming. It says the main culprit is the burning of fossil fuels that send heat-trapping greenhouse gases into the atmosphere.
Consensus	1840929642	...the scientific consensus that global warming exists and is caused by people.
	1764608902	More than 95 percent of climate scientists agree that recent global warming is caused mostly by human activity.
	2138968948	...the established scientific consensus that climate change is occurring and is primarily the result of human activity.
	434050139	...broad scientific consensus linking [heat-trapping greenhouse gases] to warming since 1950.
Highest CO_2	1888882605	The last time atmospheric CO_2 levels were as elevated as they are today, three million years ago, sea levels were most likely 45 feet higher, and giant camels roamed above the Arctic Circle.
	431177088	[P]resent-day atmospheric levels of heat-trapping carbon dioxide are higher than at any other time in the last 420,000 years.
	1350839635	Last week, scientists announced that the concentration of heat-trapping carbon dioxide in the atmosphere had reached 400 parts per million—its highest level in at least three million years.
	433470176	For at least 600,000 years before the Industrial Revolution, the concentration of carbon dioxide rarely nudged beyond 280 parts per million. It is now 382 parts per million and rising steadily.
Permanent	1010314252	By then, they say, the atmosphere would contain so much carbon dioxide as to make a substantial warming inevitable, and the gas would not return to a normal level for thousands of years.
	921555176	[C]arbon dioxide, the primary cause of climate disruption, persists in the atmosphere for thousands of years.

years with no climate-change news articles (1985 and 1987), no black circle is drawn. For each year, the blue shading gives the Bayesian posterior probability density function (PDF) $P(\theta)$ for the probability θ of a climate-change news article containing the fact (appendix D); in what follows, we also refer to θ as the prevalence. For this Bayesian analysis, a uniform prior is used (therefore, 1985 and 1987 have uniform posterior PDFs).

To get a sense for the time-dependence of θ for each fact, we calculate a best-fit line parameterized by the beginning probability θ_b for January 1, 1983 and the ending probability θ_e for January 1, 2019, using Bayesian analysis with uniform priors for both θ_b and θ_e (appendix E). These best-fit lines are shown in black in figure 2. Figure 3 displays the median value of θ_e for each fact with the 95% central credibility interval given at the bottom of each pie chart.

We see that the prevalence of the Warming Now fact has remained fairly steady over the three and a half decades of data here. In the linear model for θ, the prevalence of the Warming Now fact likely increased modestly from $\theta_b = 20\%$ (95% CI: [9%,31%]) in 1983 to $\theta_e = 31\%$ (26%,37%) in 2019. In sharp contrast, the prevalence

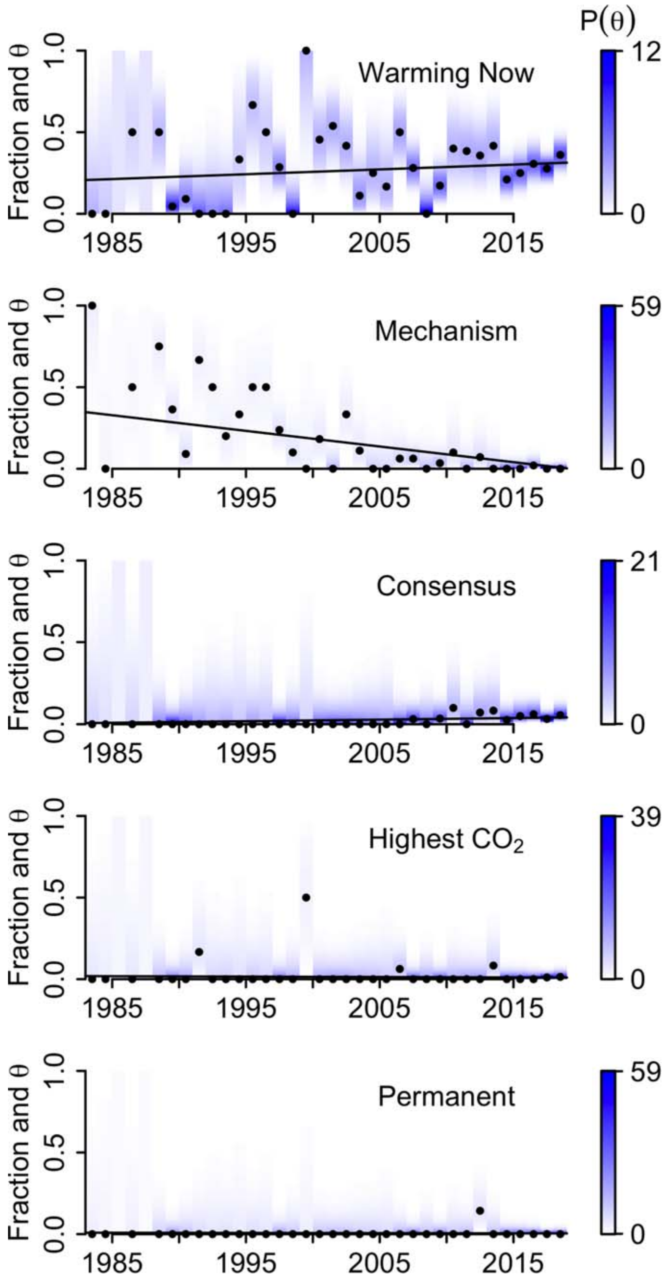

Figure 2. Prevalence of the five facts as a function of time. Black circles denote the fraction of climate-change news articles that contained the fact. Blue shading gives the posterior PDF for the prevalence θ. Solid black lines are best-fit lines to the posterior PDFs, which overlap the abscissa in the lower panels.

of the Mechanism fact has decreased from $\theta_b = 34\%$ (26%,43%) in 1983 to essentially zero in 2019 with $\theta_e = 0.2\%$ (0.008%,1%). This is unfortunate because an understanding of the mechanism of global warming strongly affects the willingness to take mitigative action [49]. It appears that journalists felt a need to explain the mechanism to their readers when the topic was new, but have since assumed, incorrectly [2], that today's readers have this knowledge.

The first article to mention the Consensus fact appeared in 2007, three years after the scientific consensus was first reported [36]. Informing people of the scientific consensus has been shown to dramatically increase their acceptance of global warming [50–54], but, unfortunately, the prevalence of this fact in climate-change articles in 2019 is only $\theta_e = 4\%$ (2%, 6%). For the Highest CO_2 fact, only 1% of all articles mentioned this fact (6 out of 597). The Permanent fact was mentioned by only 0.3% of all articles (2 out of 597). Based on the distribution of these occurrences in time, the best-fit linear model gives a prevalence for 2019 of 1% (0.2%, 2%) for the Highest CO_2 fact and 0.4% (0.03%, 1%) for the Permanent fact.

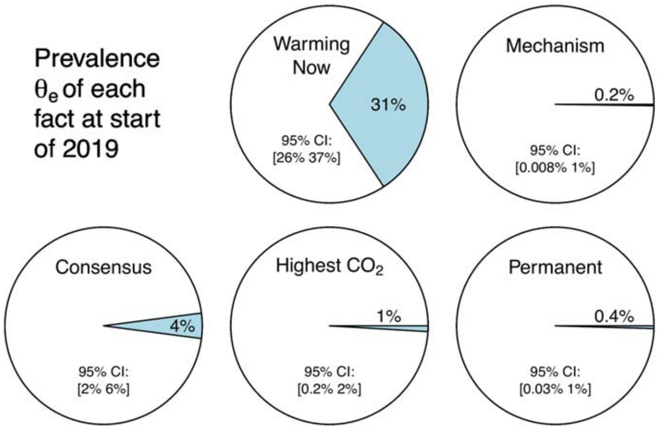

Figure 3. Prevalence θ_e of the five facts in *New York Times* climate-change news articles at the start of year 2019. Median values are presented with one significant digit.

4. Conclusion

This study quantifies the presence or absence of basic climate facts within climate news articles of a major national newspaper. In an analysis of nearly six hundred news articles in *The New York Times* (NYT) that cover climate change, we find that, with one exception, basic climate facts appear in those articles today with vanishingly small frequencies. The one exception is the fact that global warming is happening now, which appears in 31% of current NYT news articles. The basic mechanism of global warming appeared with a similar prevalence (34%) in the early 1980s, but has dropped to a prevalence of essentially zero today (0.2%). The other facts—the scientific consensus on global warming and its human cause, the fact that CO_2 concentrations are higher now than any other time in human existence, and the fact that global warming is effectively permanent—appear today with similarly small frequencies (4%, 1%, and 0.4%, respectively). In fact, the vast majority of climate-change news articles contained none of the five basic climate facts. Since the NYT is highly regarded for its coverage of news in general, and of science and global warming in particular, it is doubtful that any other major newspaper fares much better.

This study confirms, in a quantitative manner, the earlier finding that climate-related newspaper articles lack the scientific context readers need to make sense of the problem [19]. By looking at a set of five climate facts within one of the United States' prestige newspapers, and searching through all articles from the past 40 years, this study provides a quantitative view into how the reporting has changed over past decades, and establishes a methodology that can be used to look for improvements in the future. In the meantime, however, we conclude that the American public is not learning basic climate science through newspaper journalism. Of course, this need not be the case: as illustrated by the snippets in table 1, the basic facts of climate science can be embedded in articles with ease. A more systematic inclusion of these basic facts within works of climate journalism would likely increase the public's concern for, and desire to stem, the growing climate crisis [9–11].

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Competing interests

The authors declare no competing interests.

Appendix A

Duplicate articles were identified by calculating a measure of approximate string matching between the full text of every article with any other article published within a two-week period. For every set of matching articles, the article with the longest word count was retained and the others were removed. String matching was calculated based on the restricted Damerau-Levenshtein distance [55]: if the restricted Damerau-Levenshtein distance between two articles, divided by the larger of the two word counts, was less than 0.5, then the two articles were identified as matches.

Appendix B

For each fact, there are some keywords or character strings that must be present for a paragraph to be able to convey that fact. For each fact, the first author read the subset of paragraphs that met the relevant criteria and then judged whether the fact was present in each of them. Using standard logic notation, and defining P_x to be true if and only if string x is present, the subset of paragraphs identified for reading were chosen as follows for each fact:

Warming Now	$P_{\text{warm}} \vee P_{\text{temperature}}$
Mech. part 1	$(P_{\text{fossil}} \vee P_{\text{coal}} \vee P_{\text{oil}} \vee P_{\text{natural gas}} \vee P_{\text{jet fuel}} \vee P_{\text{methane}} \vee P_{\text{gasoline}} \vee P_{\text{petrol}})$ $\wedge(P_{\text{carbon dioxide}} \vee P_{\text{greenhouse gas}} \vee P_{\text{greenhouse}-\text{gas}} \vee P_{\text{co2}})$
Mech. part 2	$(P_{\text{carbon dioxide}} \vee P_{\text{greenhouse gas}} \vee P_{\text{greenhouse}-\text{gas}} \vee P_{\text{co2}}) \wedge (P_{\text{trap}} \vee P_{\text{heat}} \vee P_{\text{radiation}})$
Mech. part 3	$(P_{\text{trap}} \vee P_{\text{heat}} \vee P_{\text{radiation}}) \wedge (P_{\text{temperature}} \vee P_{\text{warm}} \vee P_{\text{hotter}})$
Consensus	$P_{\text{warm}} \vee P_{\text{temperature}}$
Highest CO_2	$[(P_{\text{hundred}} \vee P_{\text{thousand}} \vee P_{\text{million}} \vee P_{,000}) \wedge P_{\text{year}}] \vee P_{\text{centuries}} \vee P_{\text{milleni}} \vee P_{\text{permanen}}$
Permanent	$[(P_{\text{hundred}} \vee P_{\text{thousand}} \vee P_{\text{million}} \vee P_{,000}) \wedge P_{\text{year}}] \vee P_{\text{centuries}} \vee P_{\text{milleni}} \vee P_{\text{permanen}}$

This preliminary screening of paragraphs, performed by a computer, allowed the first author to judge the presence of facts in all 597 articles in a timely manner.

Appendix C

Let us index years by a subscript i and let n_i be the number of articles in that year. For a particular fact, let k_i be the number of articles that contained that fact (although there are five different facts being studied here, we omit an index corresponding to the fact for notational simplicity). For year i, let θ_i be the underlying probability that an article written in that year will contain the fact; we also refer to θ_i as the prevalence. For the Bayesian analysis, we use a uniform prior for this probability: the prior probability density function is $P(\theta_i) = 1$ for $0 \leqslant \theta_i \leqslant 1$ and zero otherwise. Given θ_i, the likelihood of observing k_i articles containing the fact out of n_i articles sampled is the binomial distribution,

$$P(k_i, n_i|\theta_i) = \binom{n_i}{k_i}\theta_i^{k_i}(1 - \theta_i)^{n_i - k_i}.$$

By Bayes' theorem, the posterior distribution (i.e. the probability density function for θ_i given an observation of k_i fact-containing articles out of n_i total articles) is

$$P(\theta_i|k_i, n_i) = \mathrm{Beta}(\theta_i, k_i + 1, n_i - k_i + 1),$$

where Beta is the beta distribution. The mean of this distribution is $(k_i + 1)/(n_i + 2)$.

Appendix D

To get a sense for the time-dependence of θ_i for each fact, and to get a best-fit present value of θ_i, we use Bayesian analysis to calculate the posterior PDFs of the variables θ_b and θ_e in the expression

$$\theta_i = \frac{\theta_b(y_e - y_i) + \theta_e(y_i - y_b)}{y_e - y_b}, \tag{1}$$

where θ_i is the probability of the fact occurring in an article in year y_i (equal to, e.g., 2 014.5 for articles published in 2014), y_b is the beginning time for this time series (1 983.0, representing January 1 of 1983, the first year with a nonzero n_i) and y_e is the ending time for this time series (2 019.0). In this model, θ_i transitions linearly from θ_b at

y_b to θ_e at y_e. Taking the prior distributions for θ_b and θ_e to be uniform distributions, the posterior distribution for θ_b and θ_e is proportional to the likelihood,

$$P(\theta_b, \theta_e | \{k_i, n_i\}) \propto \prod_i \binom{n_i}{k_i} \theta_i^{k_i} (1 - \theta_i)^{n_i - k_i},$$

where θ_i is given by the linear model of equation (1). The properties of this posterior distribution (i.e., the medians and credibility intervals of the marginal distributions of θ_b and θ_e) are calculated with the Markov chain Monte Carlo method via the Metropolis algorithm. The lines plotted in figure 2 use the median values of the marginal distributions for θ_b and θ_e.

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