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The socio-epistemic constitution of science and technology in the Greek press: an analysis of its presentation

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This paper aims to analyze the way in which the Greek press treats the socio-epistemic constitution of science and technology. By "socio-epistemic constitution" we mean the following dimensions: (a) techno-scientific methodology, (b) the social organization of the techno-scientific endeavor, and (c) the interactions of science and technology with other public spheres. Our methodology is based on a content analysis of a sample consisting of 1,867 relevant articles from four national Greek newspapers. The analysis showed that although there is a constant flow of techno-scientific articles, the internal aspects (methodology and internal organization) of science and technology become apparent in only a small minority of these articles. By contrast, external relationships, mainly with politics and economics, are emphasized by focusing on the positive social impact of the techno-scientific endeavor. In general, the Greek press makes a positive contribution to the advancement of the public understanding of science and technology, as the prominent presentation of some of their socio-epistemological components forms a realistic "post-academic" image of these two areas.

1. Introduction

The press constitutes a major source of information about scientific and technological issues for the general public and provides the framework within which most people are able to talk about and conceptualize science and technology.[1] In particular, the press does not simply mediate the scientific information but also shapes it, changing some of its most critical features—a typical function called "framing"—before it reaches the public. "Framing" is taken to mean the conceiving of press discourse as a set of "*largely unspoken and unacknowledged"* interpretive packages that give meaning to an issue.[2] The "frames" reflect broader cultural resonances and press values.[3] They are constructed by specific editorial and journalistic practices (e.g., positioning of an article in a column, type of sources used, etc.), as well as by a range of discursive choices at the level of semantics (e.g., elements of semantics emphasized or underrepresented in the bulk of the total coverage of an issue). A considerable body of empirical research has shown that the press's "frames" have considerable influence on the way the public feels, thinks, and acts about issues related to science and technology.[4] As a

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result, the press plays an important role in the advancement of the public understanding of science and technology.

One of the most crucial dimensions of this understanding is an awareness of the way science and technology construct facts and artifacts. This kind of understanding is usually described in the relevant literature as an understanding of the methodological and sociological issues of techno-scientific work (socio-epistemic constitution of science and technology) and is particularly crucial for maintaining public attention toward the relevant issues.[5] Issues of this kind are typical of "science and technology in the making," in the sense that the corresponding claims may not as yet have been very well established as facts within the corresponding research communities; thus they are usually contested in the public domain in terms of both methodological issues as well as issues concerning techno-scientific work as a socially organized process (e.g., trustworthiness and credibility of techno-scientific institutions; social shaping by various social actors, etc.).[6]

Many international studies have shown that the general public exhibits a very low level of understanding of the elements comprising the socio-epistemic constitution of science and technology.[7] For example, according to Jon Miller, only 12 percent of the European, and a corresponding 21 percent of the American, public seems to have a satisfactory understanding of techno-scientific methodology.[8] The same researcher, in his biennial measurements of the level of the public understanding of science and technology in the United States, has found that only 2 percent of the American public understands science as the development and testing of theory; another 21 percent thinks of all scientific inquiry as a form of experimental investigation; an additional 13 percent understand science to be based on careful and rigorous comparison, often involving precise measurement, while the remaining and impressively large 65 percent shows no sign of understanding the nature of scientific inquiry.[9] Another study by Bauer and Schoon, in line with the findings of the previous studies, revealed that in five European Union countries, the general public has a very vague idea of the way science and technology are actually conducted.[10] In four of the countries, the majority of the public mentioned some kind of institutional organization of the techno-scientific process, but only in two countries (Holland and Luxembourg) did most of the general population show an understanding of the fact that science and technology are socially organized endeavors governed by specific social rules.

The low level of public understanding of the nature of techno-scientific work has very important implications for the tensions existing between lay people and the institution of science and technology. As Yearley points out: "If the public has an idealized notion of what scientific activity is like, if citizens are encouraged to think that the truths of science descend like the apples from Newton's tree, they will expect too much of scientists or may be dismayed when scientists disagree."[11]

Taking into account such considerations, this paper aims to analyze the way in which methodological elements and the social organization of techno-scientific work are presented, or framed, in the Greek press. This study constitutes part of a broader project aiming at analyzing the image of science and technology in texts in the public domain (press and science textbooks). In particular, apart from the issues related to the methodology and the social organization of techno-scientific work, this broader project analyzes the specialized content of science and technology as it appears in press articles and the corresponding expressive modes (both linguistic and visual-representational) deployed. The analysis of the techno-scientific texts of the press parallels a similar analysis of the same dimensions in science textbooks.

Regarding our two dimensions of focus—methodology and social organization—we can say that they comprise the so-called socio-epistemic constitution of science and technology. The elements that comprise these socio-epistemic components can be traced to the epistemological positions of the inductivists, Popper and Lakatos, and especially Kuhn and

are complemented by the internal and external sociologies of techno-scientific knowledge.[12] Inductivism and hypothetico-deductivism focus mostly on the logical and methodological essence of these areas.[13] This approach understates the role of social factors in the formation of techno-scientific knowledge. Kuhn, through his notion of "paradigm" and its assigned circular meaning of "what the members of a scientific community share, and, conversely, a scientific community consists of men who share a paradigm," directs the academic spotlight onto the function of each specialized community, which is a fundamentally sociological issue.[14] This approach is compatible with the internal sociology of science and technology of Robert Merton.[15] Merton argues that the scientific community is guided by the norms and ethos of good practice, summarized in a set of norms like communalism, universalism, disinterestedness, originality and skepticism (CUDOS). Merton, however, considers the social elements as external to techno-scientific knowledge or, to use a terminology that SSK has adopted, Merton has "black-boxed" the content of science and technology. Merton's internal sociology has been deepened by empirical studies aimed at revealing the significance of social factors within the techno-scientific community in the formation of the corresponding knowledge content.[16] The picture of the socio-epistemic constitution of science and technology is finally complemented by the external sociologies of science and technology, which explore the function of social forces and actors (political, economic, cultural, etc.) acting in the wider social arena in a way that shapes the production of the techno-scientific knowledge itself.[17]

The theoretical stances briefly discussed above determine the dimensions of our analysis concerning the socio-epistemic constitution of science and technology, which are as follows:

- Methodologies and criteria for concluding and theory-building,
- The social organization of the production of techno-scientific knowledge, and
- Identification of the wider social factors involved in the production and reproduction of techno-scientific facts and artifacts.

2. Methodology

In order to analyze the socio-epistemic constitution of science and technology as presented in the Greek press, a sample of 1,867 relevant articles were selected from four Greek newspapers (*Vima, Eleftherotypia, Eleftheros Typos*, and *Kathimerini*).[18] The criteria for selecting these four newspapers were: (a) their national outreach, (b) their broad readership, (c) the representativeness of their political orientation, and (d) the fact that all contain special sections about science and technology.[19] The issues of the four newspapers examined cover the period from January 1996 to December 1998. This period was selected because of its richness in significant techno-scientific events that had intense coverage in the international press.[20]

The sampling procedure for selecting the 1,867 articles was that of the "constructed week," by which we mean a series of the seven weekdays (Monday through Sunday), which correspond to non-consecutive dates so as to reduce the distortion of any single news event. Specifically, for each newspaper, four constructed weeks per year of the period examined in this study (1996–1998) were selected. This procedure ensured that all the days of the week were equally represented in our sample, to take into account all the possible daily variations in the coverage of science and technology (for instance, the special sections of each newspaper are released on a specific day). The only exception to this sampling procedure was *Vima*, since it was a Sunday paper during the period covered by the study. In order for *Vima* to contribute to the total sample proportionate to the dailies (in terms of their issues' total printed area) it was calculated that 17 Sundays per year of the study should be randomly selected. The total number of issues selected per year and per newspaper is, according to Stempel, considered to be highly representative

of the coverage for a whole year, since every sample consisting of 6,12,18, 24, and 48 days in a year is quite representative, with those consisting of more than 12 days being a little more reliable.[21]

Apart from the sampling procedure, a further crucial methodological question concerns which articles are to be selected as related to science and technology. The methodological approach adopted on this issue was the establishment of a series of criteria as broad as possible that, on the one hand, would allow the identification of these articles but, on the other, would prevent the loss of critical information due to too narrow a consideration of what constitutes a scientific or technological article. The criteria we reached are as follows:

- A clear focusing on issues related to science and technology,
- The use of scientific or technological sources, and
- The use of scientific or technical language (terminology) or more generally, of a corresponding code (scientific or technological visual representations).

Following this procedure, we analyzed articles referring to: Information Technology–Electronics (31.7%), Biology–Biotechnology (18.1%), Engineering (16.4%), Environmental Sciences (12.0%), Astronomy (8.2%), Physics–Chemistry (7.3%), and Earth Sciences (5.6%). Despite the fact that the various techno-scientific fields might be presented differently, in this study we were interested in the broad picture of the socio-epistemic constitution of science and technology as portrayed by the Greek press, so we will treat all of them in an aggregate way. Articles about astrology, weather forecasts, medical issues, social sciences (e.g., psychology, sociology, social anthropology, etc.), cars and motorcycles, and advertisements were excluded from our sample, despite the fact that some of them might fall within the criteria mentioned above.[22]

The articles within the sample were then subjected to a content analysis on the basis of a research instrument specifically developed for the needs of this study. The instrument developed consists of variables grouped into four broad units (see Appendix).

The first unit of the research instrument contains variables that concern, on the one hand, the elements of the journalistic coverage of the techno-scientific articles and, on the other, their prominence within the whole newspaper's layout. Specifically, the variables of the first type in this unit are: (a) the type of column each article belongs to; (b) the domain of expertise of its author; (c) the origin of the story (sources); (d) the main event reported; and (e) the main actor in each article's story line.[23] The variables coded for determining the techno-scientific articles' prominence are: (a) the printed area covered by each article in square centimeters and (b) the Budd score, which is an objectified measure of an article's potential to attract a reader's attention.[24] Consequently, the variables of this unit mainly code the general way in which science and technology are covered in the Greek press, and so they provide background information about our central research question.

The other three units of the content analysis instrument basically correspond to the three dimensions (methodologies and rational procedures for drawing conclusions, internal sociology, and external sociology) that comprise the socio-epistemic constitution of science and technology as described in the introduction to this paper. Specifically, the unit of the instrument corresponding to the methodological procedures and the procedures for concluding and theory-building in science and technology contain the variables: (a) the extent of reference to the applied techno-scientific methodologies in the articles (as a percentage of the total number of words referring to methodological issues in relation to the total number of each article's words); (b) the kind of methodology (hypothesis testing, experimentation, rigorous and precise measurement and observation); (c) the reference or lack thereof to the name of the researcher(s); (d) the epistemological image of science and technology (inductivism, deductivism); and (e) the

way in which the techno-scientific knowledge changes (accumulation of facts, revolutionary innovations).[25]

The unit of the instrument corresponding to the internal sociology of the techno-scientific work contains the variables: (a) the type of institutions in which the scientific or the technological progress takes place; (b) the dimension of communality (as opposed to individual endeavor) of the techno-scientific work; (c) the kind of social interactions among the members of the techno-scientific community during the process of producing the corresponding knowledge or technological artifact (consensus, controversy); and (d) the reference to procedures that typically the members of the techno-scientific community follow for the diffusion and validation of the new knowledge within their specialized communities (e.g., publications and congress announcements).[26]

Finally, the third unit of the instrument that corresponds to the external sociology of science and technology contains the variables: (a) the reference to interactions of science and technology with other spheres of human activity (e.g., politics, economics, culture/education, religion/philosophy, etc.); (b) the kind of social impacts of science and technology (e.g., negative, positive, mixed, neutral); (c) the areas of public life mostly influenced by the impact of science and technology; and (d) the social agents that reap the cost or benefit from the social impacts of science and technology.[27] A more detailed presentation of the research instrument can be found in the Appendix at the end of the paper.

3. Results

Elements of journalistic coverage and prominence of the science and technology articles

Issues about science and technology are regularly covered in the Greek press, since the average number of relevant articles per issue for the three dailies in our sample (*Kathimerini, Eleftheros Typos*, and *Eleftherotypia*) is in the order of 4 to 5, while for the Sunday newspaper (*Vima*) it is about 15 to 16 articles. Taking into consideration that the average size of the techno-scientific articles is 313 cm^2 in the three dailies and 382 cm^2 in the Sunday paper, it can be calculated that science and technology occupies 1.5–2.5 percent of the total printed area of the newspapers in our sample. This percentage of techno-scientific coverage in the Greek press is comparable to that found in similar studies of the press in other countries. For instance, Bauer *et al.* found that science and technology cover 5 percent of the British press; Pellenchia, using a narrower definition of what constitutes a techno-scientific article, found a percentage ranging around 2 percent for the U.S. press, while Gasgoine and Metcalfe found 2.9 percent for the Australian press.[28]

In order then to estimate the relative importance attributed by the Greek press to science and technology, the extent of coverage of these two areas was compared to the corresponding extent of coverage of two other areas of public life: politics and sports. This comparison revealed that political coverage corresponds to percentages ranging from 14–26 percent, depending on the newspaper, while sports coverage occupies on average around 15 percent of the total printed area of the four newspapers. It is obvious that, despite the constant flow of relevant news, science and technology are covered far less in the Greek press when compared with politics and sports. This result is in sharp contrast to the self-reported relative interest of the Greek public about these three areas (this is a wider phenomenon in Europe, not particular to the Greek case).[29] This low prominence of science and technology in the Greek press is further reinforced by the findings that the majority of the articles (58.5%) are less than one-third of the area of a tabloid page and that 86 percent of the articles are characterized by a small or medium Budd score. This picture of the low prominence of techno-scientific articles is in full

accordance with the findings of other studies of the international press.[30]

As far as the elements of journalistic coverage of science and technology are concerned, the analysis showed that:

- *Type of Column*: Forty per cent of the articles are located in the news columns (either domestic or international), while a significant additional 30 percent belongs to the specialized sections about science and technology that all the newspapers of our sample have. A smaller, 14.2 percent, of the articles are in the financial sections of the newspapers.
- *Author*: Only 26.7 percent of the articles are written by specialists (members of the techno-scientific community comprised 4.3% of this figure and specialized journalists 22.4%), whereas a considerable percentage—44.5 percent—consists of unsigned articles. Finally, 28 percent of the articles are written by non-specialist journalists.
- *Sources*: The most frequently used sources (40%) in the techno-scientific articles are journalistic ones (i.e., personal journalistic investigations, "leaks," and wire news services), followed by expert sources (26.7%) (techno-scientific publications or citations of members of the techno-scientific community), while 26 percent of the articles used sources related to the state authorities and the industrial world. Social organizations, such as ecological groups or consumer protection unions are used as sources in only 6.9 percent of the articles.
- *Main events*: The main kinds of events presented in the techno-scientific articles are: (a) technological/scientific innovations and applications (35.7%); (b) events related to science policy and the effects of science and technology on the economy (22.3%), and (c) negative events such as natural and technological disasters, accidents and risks (20.2%). By contrast, articles referring to events concerning techno-scientific activity per se (e.g., specialized congresses, episodes of research, etc.) and to the way the natural world works are far more rare (14.2% and 7.5%, respectively).
- *Main actors*: In line with the results of the previous variable, the main actors of the articles' story lines are: (a) material agents (usually high-tech devices and various substances: 36%); (b) humans (22.1%) of whom 3.7 percent are scientists; and (c) representatives of state and business institutions (22%), whereas the elements of the natural world (e.g., flora, fauna, celestial bodies, ecosystems, etc.) appear more rarely as main actors (17.4%).

Summarizing the results from this unit of the research instrument, one can say that science and technology, although not receiving very prominent coverage in the Greek press, still appears regularly in it. The techno-scientific articles are usually encountered in the news and the specialized sections of the newspapers and are written mainly by non-specialists. Most of them focus on technological innovations and applications, science policy issues, the effects of science and technology on economic life, and the negative aspects of techno-scientific activity like technological disasters, accidents, and risks. However, techno-scientific activity *per se* does not seem to be a central issue of the techno-scientific press coverage. This general description of science and technology in the Greek press seems to be typical, since it concurs, in its most basic conclusions, with all the relevant international studies.[31]

Elements of the epistemological constitution of science and technology

The analysis showed that the methodological and rational aspects of science and technology are "black-boxed" in the vast majority of the relevant articles in the Greek press. Specifically:

- *Extent of reference to the applied techno-scientific methodologies*: In 72.2 percent of the articles there is no reference to the techno-scientific methodologies at all; even in the remaining 27.8 percent in which such a reference does exit, it is usually very short and

superficial (the mean number of words referring to methodological elements per article is 40 or the mean percentage of words referring to methodological elements per article is 3.9%).

- *The kind of techno-scientific methodology*: The "methodologies" of techno-scientific inquiry that this latter category of articles characteristically presents are that of *precise and rigorous measurement and observation* (19.2%) followed by the method of *experimentation* (6%) and that of *hypothesis stating and its subsequent testing* (2.6%).
- *The reference to the name of the researcher(s)*: Science and technology are presented as impersonal bodies of knowledge, since in 71.6 percent of the articles there is no reference to the names of the protagonists of the techno-scientific endeavor, these being the members of the relevant specialized communities.
- *The epistemological image of science and technology*: Naturally the lack of basic information about the methodological aspects of science and technology in the articles leads to the finding that the content of 86.1 percent of them does not allow for an identification of any clear epistemological position of these two areas. In the remaining small percentage of articles in which such identification is possible (13.9%), the prevailing epistemological position is the inductive one (accumulation of data leading to the formation of general theories), while the hypothetico-deductive position (theories stated as hypotheses confirmed by data) was identified in only 2.5 percent of the articles.
- *The way techno-scientific knowledge changes*: Finally there is no reference to the way that techno-scientific knowledge changes in 60.7 percent of the articles. In the rest of the articles where such reference is made, innovative and revolutionary ways (25.2%) outweigh the cumulative way of change (14.1%).

As shown in Table 1, which summarizes this part of the analysis, the press does not refer extensively to the epistemological constitution of science and technology, thereby not allowing the lay reader to acquire an understanding of the techno-scientific method of inquiry that leads to the construction of the relevant truths and artifacts.

Table 1. The epistemological constitution of science and technology in the Greek press.

Element	Percentage of articles that make some reference	Prevailing feature
Methodologies	27.8	Rigorous and precise measurement
Name of researchers	28.4	—
Epistemological position	13.9	Inductivism
Way of change of the techno-scientific knowledge	39.3	Innovative, revolutionary

If we define reference to the epistemological constitution of science and technology as *extensive* where at least three elements of Table 1 co-exist in the same article, and as *restricted* if otherwise, then it can be calculated that only 11.3 percent of the articles are characterized by extensive reference to the epistemological constitution of science and technology as shown in Figure 1.

The absence of the methodological elements of science and technology is a feature that all the relevant international studies have identified in examining the way press covers these two areas.[32] Evans and colleagues, for instance, point out that "The image of science in the press is one of a disembodied enterprise... There is little discussion of research procedures, and the reported findings are seldom related to other findings. Also, the limitations of research efforts are rarely noted."[33]

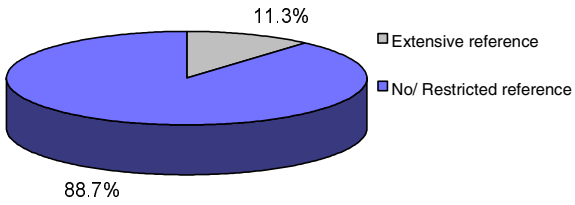

Figure 1. Percentage distribution of articles by extent of reference to elements of the epistemological constitution of science and technology.

The social organization of techno-scientific work

The findings regarding this dimension revealed that the interior social mechanisms within the techno-scientific communities, being constitutive of the production of corresponding knowledge and artifacts are, as in the case of the methodological elements, black-boxed by the Greek press. In particular, the specific results that led to this conclusion are the following:

- *Type of institutions in which the scientific or technological progress takes place*: In almost one in two of the analyzed articles (53.4%) there is no reference at all to the techno-scientific institution in which the corresponding work is taking place. In the rest of the articles, the most frequently identified type of research institution is industry (16.6%) followed by the university (14.6%), state institutions (11.0%), and research centers (4.5%). The pattern that emerges from this variable is that the majority of the research institutions mentioned in the Greek press correspond to non-academic institutions (27.6%—industry, state) rather than academic ones (19.1%—university, research center).
- *Degree of communality of the techno-scientific work*: Two-thirds of the articles (66.7%) do not state anything about the degree of communality of the techno-scientific work. The remaining one-third, however, show that the techno-scientific work is done either by one specific research team (11.1%) or through the cooperation of several research teams (10.1%). The model of the one isolated research scientist as a "lonely seeker after truth" is rarely present in the articles (8.9%), while there is also a small percentage of articles (3.4%) that attributes techno-scientific achievements to the techno-scientific community in general. It is evident from this result then, that whenever the press refers to the degree of communality of the techno-scientific work, it presents science and technology mostly as products of teamwork rather than of the inspiration of a gifted individual scientist or engineer. This finding is in sharp contrast to the findings of similar studies that show that the press usually presents science and technology as the product of individual geniuses.[34]
- *Kind of social interaction among the members of the techno-scientific community*: Almost four out of five articles (79.7%) provide no indication of any kind of social interaction (negotiation) among the members of the techno-scientific community while producing new knowledge or artifacts. This constitutive element of the techno-scientific process is apparent in only 20.3 percent of the articles. Of these, 16.4 percent present the social interaction among the members of the techno-scientific community as leading to consensus, while the rest (3.9%) show it as leading to controversies.
- *Reference to procedures of diffusion and validation of the new knowledge within the techno-scientific communities*: Last, but by no means least, the vast majority of the articles (93.4%) hide the mechanisms by which the new techno-scientific knowledge is diffused and validated among the specialized communities (the Mertonian norm of communalism): only 3.4 percent of the articles refer to the mechanism of communicating the latest research

results to the wider community by publication. An additional 3.2 percent refer to the same process by announcements to specialized conferences.

Table 2 summarizes the results and basic conclusions from the analysis of the way the social organization of techno-scientific work (internal sociology) is presented in the Greek press. As shown, the Greek press does not withdraw the veil concealing the principles governing the techno-scientific community as a socially organized group, an approach similar to its treatment of the methodological elements of science and technology.

Table 2. The social organization of the techno-scientific work in the Greek press.

Element	Percentage of articles that make some reference	Prevailing feature
Type of institution	46.6	Non-academic institutions
Collectivity	33.3	Team-work
Social interaction (negotiation)	20.3	Consensus
Communalism	6.6	—

This finding can be verified if we estimate the proportion of articles that have an extensive reference to the elements of the social organization of the techno-scientific process in relation to the articles that have restricted or no reference to these elements at all. The meanings of the values *extensive* and *restricted reference* are defined with reference to the epistemological constitution (extensive reference is equivalent to the co-existence in the same article of at least three elements of the social organization, restricted reference if otherwise). Following this procedure, we arrive at the conclusion that only 15.7 percent of the articles contain extensive references to the social organization of the techno-scientific process (see Figure 2).

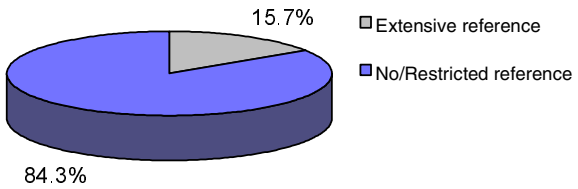

Figure 2. Percentage distribution of articles by extent of reference to elements of the social organization of the techno-scientific process.

The fact that there is a striking similarity between the percentages of articles with an extensive presentation of the methodological elements of science and technology and those that make extensive reference to their social organization (11.3% and 15.7%, respectively), leads to the hypothesis that these two distinct dimensions of the internal functioning of the techno-scientific process might be interrelated in the press. This hypothesis was indeed supported ($\chi^2 = 550.06$, df $= 1$, $p < 0.001$, $N = 1{,}867$), leading to the conclusion that the articles that make extensive reference to the methodological elements of science and technology also make extensive reference to the way that the corresponding process is socially organized. Therefore, the articles that make extensive reference to the internal mechanisms of techno-scientific knowledge production (both in relation to methodologies and elements of social organization) constitute 9.5 percent of all the articles in our sample. What is even more interesting is that no statistically significant relationship exists between the kind of column (specialized column about science and technology or column of general interest) and the extent of reference to the internal mechanisms of the techno-scientific process in the articles,

or between the kind of author (specialist or generalist) and the extent of reference. On the contrary, it seems that a statistically significant relationship does exist between the size of the articles and the extent of reference to the internal mechanisms of science and technology in them ($\chi^2 = 34.6$, df $= 1$, $p < 0.001$, $N = 1{,}867$), with the larger articles including more extensive accounts of the methodological and sociological elements of the techno-scientific process. This relationship may reflect a generalized journalistic practice to consider these elements as non-central to the coverage of the corresponding issues, and so to include them in the articles as superfluous information when the space constraints allow them to do so.[35] Such practice could be accounted for by a widely held journalistic belief that incorporating the internal mechanisms of the techno-scientific knowledge production would add unnecessary complexity to the articles' content as well as dilute its authority. As Neidhardt points out "clear-cut messages are easier to communicate than information that is qualified with restricted conditions and that includes the elements for its own devaluation."[36]

The external sociology of science and technology

In sharp contrast to the conclusions drawn from the previous units of our research instrument, which show that the Greek press keeps the internal mechanisms of science and technology out of the public vision, the techno-scientific articles seem to include many elements concerning the external sociology of these two areas or, to put it differently, to the way that science and technology interact with the other spheres of the public domain (e.g., politics, religion, philosophy, the economy, etc.). This conclusion is based on the following findings:

- *Kind of social impacts of science and technology*: The vast majority of the articles (93.4%) refer to the social impacts of science and technology. These social impacts are described in most cases as positive (59%), while a considerable percentage of articles (30.9%) focus on the negative social impacts of science and technology. It is quite interesting that only a small percentage of articles present a mixed picture (positive and negative impacts) (3.8%) as far as the social impacts of science and technology are concerned.

  The same picture of a basically positive tone accompanied by a considerable amount of skepticism concerning the social impact of science and technology emerges also from a number of similar studies on the international press.[37] Despite this overall picture, the results of similar studies on the international press show a remarkable sensitivity to the particularities of each national context. Such variations could be explained by the different phases of each society's socio-economic development, which in turn determines the functions of science and technology within each society and consequently forms up to a certain extent the public's particular attitude toward science and technology. The press seems partially to reflect these generalized attitudes.[38] Specifically, the Greek public has ambivalent attitudes toward the social impacts of science and technology.[39] This seems to be reflected in the optimistic way the Greek press covers the relevant issues, though this is tempered by a considerable level of concern.
- *Areas of public life mostly influenced by the impacts of science and technology*: The social impacts of science and technology as presented in the Greek press are mostly related to matters of: (a) quality of life (health, security/safety, recreation, etc.) (40.8%); (b) the economy and politics (creation/job loss, working conditions, increase of income, business profits and losses, business competition, quality of services and products, political stability/unrest, political controversies) (20.3%); (c) ecology and environment (biodiversity and conservation of species, pollution, climatic changes, exhaustion of natural resources, deforestation) (16.1%); (d) science and technology in particular (knowledge production, manpower mobility, infrastructure) (13.5%); and (e) culture,

ethics, and morality (education, culture, fine arts, moral status, religious faith) (9.3%). The only field, according to the press, where the negative impacts of science and technology outweigh the positive ones is that of ecology and environment.

- *The social agents paying the cost or benefiting from the effects of science and technology*: In almost three-fourths of the cases, the agents that are shown to either benefit or lose from the social impacts of science and technology are humans. This result contributes to a picture already revealed by other similar studies, according to which the press coverage of science and technology can be characterized as "human-centered."[40]
- *Reference to interactions of science and technology with other spheres of the public domain*: Apart from the extensive reference in the Greek press to the social impacts of science and technology, there are also very frequent accounts (in 54.5% of the articles) of their close links to other spheres of public life. These links are usually emphasized either by showing how science and technology are integrated in the main functioning of these spheres, or by demonstrating the way in which the independent functioning of these spheres affects the direction of the techno-scientific work. The spheres of public life in which science and technology seem to have the most privileged relationships are those of the economy (28.9%) and politics (24.6%). Areas like philosophy/religion (5.4%) and culture/art (5.2%) are presented as having weaker relationships with science and technology.

The emphasis on the external sociology of science and technology by the press as shown in Figure 3, helps the lay reader understand the interdependency of these two areas within highly complex social systems like politics and the economy.

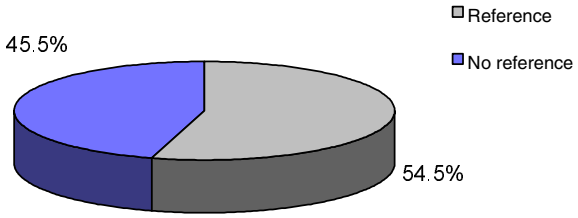

Figure 3. Percentage distribution of articles by reference to the relationships of science and technology with other spheres of the public domain.

On the other hand, stressing the social impacts of science and technology creates an image of a double-edged sword for these two areas, in the sense that they can play either a positive, instrumental role in the service of mainly political and economic forces, and thus contribute to the solution of practical problems, or they can create new risks and problems for humanity.

4. Discussion

All the Greek newspapers examined here constitute a significant "window" through which science and technology can become visible to the general public, since there is a constant flow of relevant news, despite its relatively low level of coverage.

Science and technology are presented in two distinct ways in terms of the corresponding articles' placement inside the overall layout of each newspaper. On the one hand, they are presented as areas of general interest, since two out of the three relevant articles are situated in the non-specialized columns, while on the other hand, they are presented as specialized

areas, since a considerable proportion of the remaining one-third of the articles are found in specialized columns.

The press attributes to science and technology a mainly *instrumental* role, either as tools for legitimizing (or more rarely de-legitimizing) political decisions or for achieving high levels of economic development. However, it is not rare for the press to consider these two areas as sources of risk and uncertainty for peoples' lives and the natural environment. On the contrary, science and technology are, in very few cases, described as vehicles for the pursuit of truths governing the functioning of the natural world or as a means of broadening the boundaries of human knowledge. In other words, the basic claim of the press about the exceptional position of science and technology does not rely as much on the uniqueness of their methodological procedures or sociological normative order, which allow for the uncovering and exploitation of the secrets of nature, as on their capacity to affect the daily lives of people and to interact with other systems in the public domain, especially those of politics and the economy.

The Greek press tends to "black-box" the internal mechanisms of techno-scientific inquiry. In this way, the press keeps in the dark the backstage of science and technology.[41] Despite this overall black-boxing, there are some elements, though related to the internal mechanisms of science and technology, that are more prominently presented by the Greek press. These are: (a) precise and rigorous measurement and observation as the dominant method of techno-scientific investigation (19.2%); (b) innovative and revolutionary change of the corresponding knowledge (25.2%); (c) the identification of mainly non-academic institutions as the sites where science and technology are cultivated (26.7%); and (d) communality as the prevailing mode of techno-scientific work (24.2%).

The latter three elements, combined with the press's emphasis on the context of the application of science and technology and on the interactions of these two areas with the domains of politics and the economy, form an image that seems to coincide with what Ziman and Gibbons *et al.* call "post-academic," as distinct from the older mode of "academic" techno-scientific enterprise.[42] This post-academic mode of techno-scientific enterprise is characterized by:

- A search for practical solutions to very narrowly defined and pressing problems,
- A prevalence of the interdisciplinary nature of techno-scientific work,
- Conducting the corresponding research within and for the sake of variety in non-academic social institutions, and finally
- A requirement for public (political and economic) accountability for science and technology.

Our overall position is that from the perspective of the public understanding of science and technology, the Greek press seems to play a positive role. More specifically, if one takes into consideration the three-dimensional definition of what constitutes the public understanding of science and technology as stated by John Miller (satisfactory understanding of the techno-scientific terms and concepts, corresponding processes, and impacts on individuals and on society), it becomes apparent that the Greek press has a significant contribution to make, especially toward the promotion of the third of these dimensions.[43]

The Greek press, by referring significantly to the social impacts and interactions of science and technology with other spheres of public life, helps the general public acquire a social map that places the social institution of science and technology in relation to the other public social institutions (especially to politics and the economy). This map could prove to be a very effective tool for promoting responsible public action whenever techno-scientific issues break out in the public arena.

Furthermore, the press, contrary to accusations (mainly from some members of the techno-scientific community) could also have a positive contribution to make in advancing public understanding about the internal organization of techno-scientific work (the second dimension of Miller's definition). This position is based on the finding, as stated earlier, that the press does present clearly certain aspects of the internal workings of science and technology in such a way that it forms a much more realistic picture ("post-academic" mode) in the public mind about the way science actually works. This is in sharp contrast to the picture formed by other "texts" in the public domain, such as science textbooks or science fiction films, which portray an image of this area that is much closer to the "academic" mode.[44]

Those critical of the role of the press in the advancement of the public understanding of science and technology tend to forget that the press has its own norms and values that resonate with the social aspects of science and technology, and they tend to base their criticisms on their belief that the press should adopt their own professional criteria in the coverage of these areas. Press coverage, though, does not aim at the persuasion of a technically informed body of experts (as is the case in the primary literature) by extensive references to the methodological elements of science and technology so as to create conditions of virtual-witnessing. On the contrary, the main objective of the press is the exposition of techno-scientific products as ready-made constructs, the presentation of which is justified on the basis of their social utility and their function as "boundary objects" lying on the boundaries of many intersecting social worlds.[45]

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Appendix. The content analysis instrument.

Variable	Values of the variable
Elements of journalistic coverage and prominence of the S & T articles	
Type of column	1. S & T columns, 2. News, 3. Features, 4. Financial News, 5. Other
Kind of author	1. Journalist (generalist), 2. Journalist (specialist) 3. Scientist/Engineer, 4. Unsigned, 5. Other
The sources	1. Journalistic (e.g., wire news service, journalistic leakage), 2. Scientific publications, 3. Scientific announcements, 4. Government–State, 5. Social organizations, 6. Business–Industry, 7. Other
The main event	1. Technological/scientific innovations and applications, 2. Political, 3. Financial, 4. Negative event (accident, disaster, risk), 5. Techno-scientific life (e.g., controversies, conferences, institutional life, etc.), 6. Function of the natural world, 7. Other
The main actor	1. Materialistic agent, 2. Humans, 3. Governmental–State institutions, 4. Business/Industry, 5. The natural world (flora, fauna, rivers, volcanoes, etc.), 6. Other
The area of the article (cm^2)	e.g., 158 cm^2
The Budd score	e.g., 4

continued overleaf.

Appendix. *Continued.*

Elements of the epistemological constitution of Science and Technology	
Extent of reference to the applied techno-scientific methodologies	Percentage of words referring to methodological issues in relation to the articles' total number of words
The kind of the techno-scientific methodology	Science and Technology as: 1. Development and testing of a theory, 2. Experimental study, 3. Rigorous and precise measurement and observation, 4. No specific method
Reference to the name of the researcher(s)	1. Yes, 2. No
Epistemological image of Science and Technology	1. Inductivism, 2. Hypothetico-deductivism
The way the techno-scientific knowledge changes	1. Accumulation of facts, 2. Innovative/Revolutionary
The social organization of the techno-scientific work	
Type of institutions	1. University, 2. Industry–Business, 3. Governmental–State Organizations, 4. Independent Research Centers
Degree of communality of the techno-scientific work	Science and Technology as accomplishments coming from: 1. Individual scientist, 2. One research group, 3. More than one research groups, 4. Techno-scientific community in general
Kind of the social interaction between the members of the techno-scientific community	1. Consensus, 2. Controversy
Reference to procedures of circulation and validation of the new knowledge	1. Publications, 2. Announcements to specialized conferences
The external sociology of Science and Technology	
Interactions of Science and Technology with other spheres of the public domain	1. Politics, 2. Economy, 3. Religion–Ethics, 4. Culture–Art–Education
Kind of social impacts of Science and Technology	1. Positive, 2. Negative, 3. Mixed, 4. Neutral
Areas of the public life mostly influenced by the S & T impacts	1. Quality of life, 2. Politics, 3. Economy, 4. Environment, 5. Culture–Art–Education, 6. Science and Technology
The social agents that pay the cost or benefit from the social impacts of S & T	1. Humans, 2. State, 3. Business–Industry, 4. Environment

References

1 INRA (Europe), *Europeans, Science and Technology: Public Understanding and Attitudes* (Brussels: European Coordination Office and Report International, 1993); Jon D. Miller, *The Public Understanding of Science and Technology in the United States: A Report to the National Science Foundation, Science and Technology Indicators 2000* (Washington, D.C: National Science Foundation, 2000); Office of Science and Technology and the Wellcome Trust, "Science and the public: a review of science communication and public attitudes towards science in Britain," *Public Understanding of Science* 10, no. 3 (2001): 315–330.

2 Todd Gitlin, *The Whole World is Watching* (Berkeley CA: University of California Press, 1980), 7.

3 William Gamson, and Andre Modigliani, "Media discourse and public opinion on nuclear power: A constructionist approach," *American Journal of Sociology* 95, no. 1 (1989): 1–37; Dorothy Nelkin, *Selling Science: How Press Covers Science and Technology* (New York: W. H. Freeman, 1995); Leah A. Lievrouw, "Communication and the social representation of scientific knowledge," *Critical Studies in Mass Communication* 7, no. 1 (1990): 1–10.

4 William Gamson, and Andre Modigliani, "Media discourse and Public Opinion on Nuclear Power"; William R. Elliott and William L. Rosenberg, "Media exposure and beliefs about science and technology," *Communication Research* 14, no. 2 (1987): 164–188; Susana Hornig Priest, "Information equity, public understanding of science and the biotechnology debate," *Journal of Communication* 45, no. 1 (1995): 39–54; Allan Mazur, "Media coverage and public opinion on scientific controversies," *Journal of Communication* 31, no. 1 (1981): 106–115.

5 Jon D. Miller, "Scientific literacy: a conceptual and empirical review," *Daedalus* 112, no. 2 (1983): 29–48; Brian Wynne, "Public understanding of science: new horizons or hall of mirrors?" *Public Understanding of Science* 1, no. 1 (1992): 37–43; Harry M. Collins and Trevor Pinch, *The Golem: What Everyone Should Know About Science* (Cambridge: Cambridge University Press, 1993).

6 Steven Shapin, "Why the public ought to understand science-in-the-making," *Public Understanding of Science* 1, no. 1 (1992): 27–30.

7 Jon D. Miller, "The measurement of civic scientific literacy," *Public Understanding of Science* 7, no. 3 (1998): 203–223; Jon D. Miller, *Science and Engineering Indicators, 1996* (Washington, DC: U.S. Government Printing Office, 1996).

8 Jon D. Miller, "The measurement of civic scientific literacy."

9 Jon D. Miller, *Science and Engineering Indicators*, *1996*.

10 Martin Bauer and Ingrid Schoon, "Mapping variety in public understanding of science," *Public Understanding of Science* 2, no. 2 (1993): 141–155.

11 Steven Yearley, "Understanding science from the prospective of the sociology of scientific knowledge: an overview," *Public Understanding of Science* 3, no. 3 (1994): 245–258, at 245.

12 Rom Harre, *The Philosophies of Science* (Oxford: Opus, 1972); Imre Lakatos and Allan Musgrave, *Criticism and the Growth of Knowledge* (Cambridge: Cambridge University Press, 1970); Karl R. Popper *Objective Knowledge* (Oxford: Oxford University Press, 1979); Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: Chicago University Press, 1970); Robert K. Merton, *The Sociology of Science* (Chicago: University of Chicago Press, 1973); David Bloor *Knowledge and Social Imagery* (London: Routledge, 1976); Nigel G. Gilbert and Michael Mulkey, *Opening Pandora's Box: A Sociological Analysis of Scientists' Discourse* (Cambridge: Cambridge University Press, 1984); Bruno Latour and Steve Woolgar, *Laboratory Life: The Construction of Scientific Facts* (Princeton: Princeton University Press, 1986); Bruno Latour, *Science in Action* (Cambridge MA: Harvard University Press, 1987); Thomas Gieryn, *Cultural Boundaries of Science* (Chicago: University of Chicago Press, 1999); Donald Mackenzie and Judy Wajcman, *The Social Shaping of Technology* (Milton Keynes: Open University Press, 1999); Michel Callon, "Some elements of a sociology of translation," in *Power, Action and Belief: A New Sociology of Knowledge?* ed. John Law (London: Routledge. 1986), 196–233.

13 Karl R. Popper, *Objective Knowledge*.

14 Thomas S. Kuhn, *The Structure of Scientific Revolutions*, p. 176.

15 Robert K. Merton, *The Sociology of Science*.

16 Bruno Latour and Steve Woolgar, *Laboratory Life*; Klaus Amann and Karin Knorr Cetina, "The fixation of (visual) evidence," in *Representation in Scientific Practice*, ed. Michael Lynch and Steve Woolgar (Cambridge, MA: The MIT Press, 1990), 85–121; Harry M. Collins, *Changing Order: Replication and Induction in Scientific Practice* (Chicago: University of Chicago Press, 1992).

17 Bruno Latour, *Science in Action*; Thomas Gieryn, *Cultural Boundaries of Science*; Donald Mackenzie and Judy Wajcman, *The Social Shaping of Technology*; Michel Callon, "Some elements of a sociology of translation."

18 *Eleftheros Typos, Eleftherotypia*, and *Kathimerini* are dailies with a Sunday edition, whereas *Vima* is a Sunday newspaper, with no daily editions.

19 According to data supplied by the Association of the Greek Newspaper Owners, the mean number of issues sold over the period covered by this study (1996–1998) for each newspaper in our sample were: *Vima* (160,000 issues), *Eleftheros Typos* (120,000 issues), *Eleftherotypia* (90,000 issues), and *Kathimerini* (70,000 issues). These circulations account for the 35 percent of the total readership of the dailies and the 65 percent of the total readership for Sunday newspapers in Greece over the period of the study. *Eleftheros Typos* and *Kathimerini* are considered conservative, while *Vima* and *Eleftherotypia* are considered liberal newspapers.

20 For instance, such events were: the cloning of Dolly at the Roslin Institute in April 1997, the intergovernmental congress in Kyoto about the control of greenhouse gas emissions in December 1997, the Pathfinder expedition to Mars in August 1997, the outbreak of mad cow disease in March 1996, and the legal battle between Microsoft and the U.S. administration during the whole of 1998.

21 Guildo H. Stempel, "Sample size for classifying subject matter in dailies," *Journalism Quarterly* 29, no. 3 (1952): 333–334.

22 The exclusion from our sample of articles about medicine and the social sciences was based the fact that in all of the Greek newspapers medical news items appear in a special section other than that of science and technology, while the articles about social sciences are never found in the science and technology section. In this way, the Greek press seems to "frame" both medicine and social sciences as areas distinguishable from the rest of the techno-scientific disciplines.

23 Similar variables have been used in Martin Bauer, John Durant, Asdis Ragnarsodottir, and Annadis Rudolphsdottir, *Science and Technology in the British Press, 1946–1990* (London: The Science Museum, 1995); Abigail Clayton, Micheline Hanckock-Beaulieu, and Jack Meadows, "Change and continuity in the reporting of science and

technology: a study of the *Times* and *The Guardian*," *Public Understanding of Science* 2, no. 3 (1993): 225–234; Edna F. Einsiedel, "Framing science and technology in the Canadian press," *Public Understanding of Science* 1, no. 1 (1992): 89–101.

24 Similar variables have been used in, for example: Martin Bauer, John Durant, Asdis Ragnarsodottir, and Annadis Rudolphsdottir, *Science and Technology in the British Press, 1946–1990*; Bharvi Dutt and K. C. Garg, "An overview of science and technology coverage in Indian English-language dailies," *Public Understanding of Science* 9, no. 2 (2000): 123–140; H. M. Kepplinger, S. C. Ehmig, and C. Ahlheim, *Gentechnik im Widerstreit. Zum Verhältnis von Wissenschaft und Journalismus* (Frankfurt: Campus, 1991); R. Budd, "Attention score: a device for measuring news "play," *Journalism Quarterly* 41 (1964): 259–262. The Budd score is calculated by adding one point for each column covered by the article's headline, each visual representation accompanying the article, plus one point if the article is located at the upper half of the page and if the article is located in any prominent page of the newspaper (front page, back page, middle page) and/or if it occupies a whole page. The idea for using this variable was borrowed from the study of Martin Bauer, John Durant, Asdis Ragnarsodottir, and Annadis Rudolphsdottir, *Science and Technology in the British Press, 1946–1990*.

25 Similar variables have been used in: William A. Evans, Michael Krippendorf, Jae H. Yoon, Paulette Posluszny, and Sari Thomas, "Science in the prestige and national tabloid presses," *Social Science Quarterly* 71, no. 1 (1990): 105–117; Marianne G. Pellenchia, "Trends in science coverage: a content analysis of three U.S. newspapers," *Public Understanding of Science* 6, no. 1 (1997): 49–68. The formulation of this variable was inspired by the answers of the American public on the issue of scientific methodology; see Jon D. Miller, *The Public Understanding of Science and Technology in the United States: A Report to the National Science Foundation: Science and Technology Indicators 2000*.

26 A similar variable has been used in William A. Evans, Michael Krippendorf, Jae H. Yoon, Paulette Posluszny, and Sari Thomas, "Science in the prestige and national tabloid presses"; Marianne G. Pellenchia, "Trends in science coverage." A similar variable has been used in: Robert A. Logan, Peng Zengjun, and Nancy Fraser Wilson, "Evaluating Assertions About Science Writing, Reporting and News Selection: A Content Analysis of the *Washington Post* and *Los Angeles Times*," Paper presented in the 5th PCST Conference, Science without Frontiers, Berlin: September 1998.

27 Similar variables have been used in Martin Bauer, John Durant, Asdis Ragnarsodottir, and Annadis Rudolphsdottir, *Science and Technology in the British Press, 1946–1990*.

28 Martin Bauer, John Durant, Asdis Ragnarsodottir, and Annadis Rudolphsdottir, *Science and Technology in the British Press, 1946–1990*; Marianne G. Pellenchia, "Trends in science coverage"; Jenni Metcalfe and Toss Gascoigne, "Science journalism in Australia," *Public Understanding of Science* 4, no. 4 (1995): 411–428.

29 INRA (Europe) *Europeans, Science and Technology: Public Understanding and Attitudes*.

30 Edna F. Einsiedel, "Framing science and technology in the Canadian press"; Sharon M. Friedman, Kara Villamil, Robyn A. Suriano, and Brenda P. Egolf, "Alar and apples: newspapers, risk and media responsibility," *Public Understanding of Science* 5, no. 1 (1996): 1–20; Neil Hutton, "Interactions between the formal UK school science curriculum and the public understanding of science," *Public Understanding of Science* 5, no. 1 (1996): 41–53.

31 Renate G. Bader, "How science news sections influence newspaper science coverage: a case study," *Journalism Quarterly* 67, no. 1 (1990): 88–96; Abigail Clayton, Micheline Hanckock-Beaulieu, and Jack Meadows, "Change and continuity in the reporting of science and technology: a study of the *Times* and *The Guardian*"; Bharvi Dutt and K. C., Garg, "An overview of science and technology coverage in Indian English-language dailies."

32 Edna F. Einsiedel, "Framing science and technology in the Canadian press"; Dorothy Nelkin, *Selling Science: How Press Covers Science and Technology;* Marianne G. Pellenchia, "Trends in science coverage"; William A. Evans *et al.*, "Science in the prestige and national tabloid presses"; Anders Hansen, "Journalistic practices and science reporting in the British press," *Public Understanding of Science* 3, no. 1 (1994): 111–134.

33 William A. Evans *et al.*, "Science in the prestige and national tabloid presses," p. 116.

34 Dorothy Nelkin, *Selling Science: How the Press Covers Science and Technology;* Urlike Felt, "Fabricating scientific success stories," *Public Understanding of Science* 2, no. 4 (1993): 375–390.

35 Anders Hansen, "Journalistic practices and science reporting in the British press."

36 Friedhelm Neidhardt, "The public as a communication system," *Public Understanding of Science* 2, no. 4 (1993): 339–350.

37 Dorothy Nelkin, *Selling Science: How Press Covers Science and Technology;* Edna F. Einsiedel, "Framing science and technology in the Canadian press"; Kristina Petkova, Martin Bauer, Pepka Boyadjieva, and Galin Gornev, "Modernization and images of science: comparing Britain and Bulgaria 1946–1994," Paper presented in 4S/EASST conference Worlds in Transition: Techno-science, Citizenship and Culture in the 21st Century, Vienna: September 27–30, 2000.

38 Martin Bauer, "Science in the media as cultural indicator: contextualizing surveys with media analysis," in *Between Understanding and Trust: The Public, Science and Technology*, eds. Meinolf Dierkes and Claudia von

Grote (Reading: Harwood Academic Publishers, 2000).

39 Jon Miller, Rafael Pardo, and Fujio Niwa, *Public Perceptions of Science and Technology: A Comparative Study of the European Union, the United States, Japan and Canada* (Madrid: Foundation BBV, 1997).

40 Anders Hansen, "Journalistic practices and science reporting in the British press"; Dorothy Nelkin, *Selling Science: How Press Covers Science and Technology*.

41 The notion of "backstage" is used here as a place "where the impression fostered by a given performance is knowingly contradicted as a matter of course"; see Erving Goffman, *The Presentation of Self in Everyday Life* (Garden City, NY: Doubleday, 1959).

42 John M. Ziman, *An Introduction to Science Studies* (Cambridge: Cambridge University Press, 1984); Michael Gibbons, Camille Limoges, Helga Nowotny, S. Schwartzmann, Pam Scott, and M. Trow, *The New Production of Knowledge* (London: Sage, 1994).

43 Jon D. Miller, "Scientific Literacy: A conceptual and empirical review." The examination of the Greek press's contribution to the public understanding of this dimension is out of the scope of this paper.

44 Peter Fensham, "School science and its problems with scientific literacy," in *Science Today*, eds. Ralph Levinson and Jeff Thomas (London: Routledge, 1997), 119–136; David Layton, Edgar Jenkins, S. Macgill, and A. Davey, *Inarticulate Science? Perspectives on the Public Understanding of Science and Some Implications for Science Education* (Driffield, UK: Studies in Education, 1993); Alberto Elena, "Exemplary lives: biographies of scientists on the screen," *Public Understanding of Science* 2, no. 3 (1993): 205–223; Annette Kuhn (ed.), *Alien Zone II: The Spaces of Science Fiction Cinema* (London: Verso, 1999).

45 Susan Leigh Star and James R. Griesmer, "Institutional ecology, "translations" and boundary objects, amateurs and professionals in Berkeley's museum of vertebrate zoology," *Social Studies of Science* 19 (1989): 387–420.

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