Facing the Credibility Crisis of Science: On the Ambivalent Role of Pluralism in Establishing Relevance and Reliability

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Science at the interface with society is regarded with mistrust among parts of the public. Scientific judgments on matters of practical concern are not infrequently suspected of being incompetent and biased. I discuss two proposals for remedying this deficiency. The first aims at strengthening the independence of science and suggests increasing the distance to political and economic powers. The drawback is that this runs the risk of locking science in an academic ivory tower. The second proposal favors "counter-politicization" in that research is strongly focused on projects "in the public interest," that is, on projects whose expected results will benefit all those concerned by these results. The disadvantage is that the future use of research findings cannot be delineated reliably in advance. I argue that the underlying problem is the perceived lack of relevance and reliability and that pluralism is an important step toward its solution. Pluralism serves to stimulate a more inclusive research agenda and strengthens the well-testedness of scientific approaches. However, pluralism also prevents the emergence of clear-cut practical suggestions. Accordingly, pluralism is part of the solution to the credibility crisis of science, but also part of the problem. In order for science to be suitable as a guide for practice, the leeway of scientific options needs to be narrowed – in spite of uncertainty in epistemic respect. This reduction can be achieved by appeal to criteria that do not focus on the epistemic credentials of the suggestions but on their appropriateness in practical respect.

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1. Science in Politics and the Economy

One of the pervasive distinctions in the history of political thought is the distinction between rule by consent and rule by competence or expertise. A classic locus of this debate is Plato's *Politeia* in which Plato argues against the rule by consent and advocates philosophers as political leaders. Philosophers are geared toward eternal ideas and for this reason place emphasis on the long-term consequences of political actions. The same idea is expressed today by the notion that devising policies adequately requires understanding the relevant subject matter. This idea is realized in many areas by including scientific experts in the process of law-making. For instance, in the US, it is the job of the National Commission on Forensic Science to improve forensic practice by drawing on scientific knowledge. Further, independent central banks in the US and the EU are supposed to direct financial policy on the basis of expert knowledge. This matter is regarded as being so intricate and so weighty that it needs to be handed over to scientific experts. At the international level, the "International Commission on Radiological Protection" (ICRP) develops recommendations that enter into the national radiation protection legislation in a vast number of countries, and the WHO Expert Committee gives advice on the selection and use of essential medicines.

However, in the public opinion, the quality of such science-based political recommendations is often regarded as suspect. Philip Kitcher diagnoses a "live skepticism about the authority of science" and sees the public trust in science seriously undermined (Kitcher 2011, pp. 16–20). In 2010, the journals *Scientific American* and *Nature* conducted a poll among their readership, which can be assumed to be supportive of science and science-literate (*Scientific American* 2010, p. 56). Still, when it came to rating the trustworthiness of scientific statements about agricultural matters such as the use of pesticides or food safety, the relevant scores hardly rose above the "neutral" level and remained well below "trust" and even more below "high trust" (*Scientific American* 2010, p. 56). In the same year, a "Eurobarometer" on science and technology produced by the European Commission confirmed the trend. 58% of the respondents agreed with the statement that one "can no longer trust scientists to tell the truth about controversial issues because they depend more and more on money from industry." 47% of Europeans attributed a tunnel vision to scientists: They look at issues in a very restricted science-and-technology sense and fail to integrate a broader human or social perspective (European Commission 2010, pp. 19–23). This was a recurrent motif in the debate about nuclear energy in Europe during the 1980s. Critics objected that scientific experts had only a very narrow notion of safety in view and neglected wider political ramifications such as the security regime indispensable for a nuclear society (Wynne 2003, pp. 406–7). Moreover, dependence of science on private research money

is believed to produce ill-founded and myopic results. Privately sponsored research is said to achieve only limited understanding (European Commission 2010, pp. 23–7). Studies on lay participation reveal that participants tend to suspect industry as being primarily driven by greed and for-profit thinking. Such motives are associated with neglecting long-term consequences and negative impacts on society and the environment (Williams et al. 2017, p. 93). Further, a survey among the supporters of the two major American political parties showed that the credibility of chunks of scientific knowledge depends on political inclination. Republicans tend to accept "production science" (relevant for promoting industry and economic growth) but to reject "impact science" (identifying human influences on the environment and human health). The latter is supposed to be politicized and, as a result, not credible (McCright et al. 2013). Such findings suggest that public trust in the appropriateness of scientific judgment is seriously sapped.

To be precise, it is not scientific knowledge in general that is met with public distrust, but rather some areas of science at the interface with society. Practice-oriented research and scientific expert knowledge is at the focus of criticism. The problem is not the Higgs boson but, e.g., nutritional research (e.g., genetically modified organisms, but also dietary recommendations), medical research (e.g., vaccination or alternative medicine), environmental research, climate change and, at times, human evolution. We observe that the trustworthiness of parts of science among the public is compromised by what is perceived as politicization and commercialization.

As far as I can see, two major deficiencies are attributed to the assessment of scientific experts, namely, incompetence and one-sidedness. Incompetence means that scientific results or recommendations are insufficiently confirmed; one-sidedness says that the research endeavor or its outcome is biased and thus merely draws a partial picture of the situation at hand. Incompetent answers are not adequately supported; one-sided or biased answers emphasize particular features at the expense of others. There is some overlap between the two, but in general incompetence is regarded as lack of reliability, whereas one-sidedness is perceived as lack of relevance. In particular, the notion of one-sidedness or bias, as used in this article, does not, in general, imply that the pertinent research is epistemically unsound. The point rather is that an issue is addressed only partially whereas the public would be better served by more comprehensive research endeavors. This is why bias in the sense employed here has primarily to do with relevance deficits and not necessarily with poor reliability. This is different in particular cases. Special kinds of bias can be tied up with methodological flaws and be epistemically faulty. This applies, in particular, to cases in which the partial picture developed is passed off as the whole story (Carrier forthcoming).

As a rule, incompetence is typically ascribed to experts in the socio-political realm, whereas one-sidedness is feared to be widespread in commercialized research. The impression of incompetence can be traced back to various misjudgments of scientists in the political arena during the past years. It is worth stressing at the outset that science is better than ever in solving intricate problems. Think of the prediction of climate change from the 1960s on or the quick identification of the complex cause of ozone layer depletion in the 1980s. Think also of the dramatic increase in computational power and solar cell efficiency in recent years. Yet in other cases, scientists were not that successful. Earlier promises regarding the defeat of infectious diseases needed to be taken back (as the problems associated with the use of DDT and with antibiotic resistance testify). Conversely, scientists warned against risks that proved to be non-existent later. Examples are the millennium bug from 1999 and the swine flu from 2009/10. Not infrequently, the public has seen scientists puzzled and overburdened, which has undermined trust in the adequacy and reliability of their judgment.

Another reason for attributing incompetence to experts is the so-called expert's dilemma, i.e., the confrontation of expertise and counter-expertise (Grunwald 2003). In parts of the public the view prevails that each science-based advice can be countered and repealed by an equally science-backed contrary recommendation. What happens to agricultural microorganisms if genetically modified Bt-corn is implemented? Does the microwave radiation emitted from cell phones pose long-term health risks to frequent users? Do usual concentrations of bisphenol A involve health hazards? You get inconsistent answers to such questions depending on which expert you ask.

A second source of the perceived reduction in quality of science-based advice is bias or the loss of neutrality. This supposition is also backed by the expert's dilemma. On this interpretation, contrasting expert judgments are produced by the politicization of science. Parts of the public share the view that scientific experts have become part of political fighting and that the parties to whatever dispute can rent, as it were, suitably inclined scientists. This rent-an-expert suspicion is bolstered by studies by Robert Proctor who showed that the American tobacco industry hired scientists who launched a mock debate about the alleged overestimation of the risk of smoking (Proctor 2011, Part III). In a similar vein, Naomi Oreskes and Erik Conway revealed that right-wing political circles had paid scientists for deliberately hiding anthropogenic climate change (Oreskes and Conway 2010).

In addition to expert dissent, unanimously shared expert bias nourishes public suspicion. In this case, it is not the opposition among the professional opinions of scientists but rather their deceiving consensus that is thought to betray expert bias. This effect is particularly striking in application-oriented industrial research. Meta-reviews of clinical studies

of new medical drugs have exposed a tight correlation between the financial interests of the sponsor of a clinical trial and its results (Davidson 1986; Bekelman et al. 2003; Lexchin et al. 2003; Sismondo 2008a, 2008b, Cochrane 2012; Elliott 2014; 2016). More specific cases in point are the largely unanimous but erroneous assessment of the beneficial influence of the hormone treatment of menopausal disorders between 1970 and 2000 (Büter 2015), the disclosure that clinical data about side-effects of Vioxx, a novel anti-inflammatory drug, had been suppressed (Biddle 2007), and the recent exposure that the efficacy of Tamiflu had been grossly overestimated in the 2000s (Cochrane 2014; 2015). In all these cases, economic interests could be shown to be at work, and in many of them, bias and unreliability emerge in unsavory unity.

Such indications of incompetence and one-sidedness have hurt the epistemic authority of the sciences involved. This decline affects their credibility among a wider audience in the first place, which is not the same thing as scientific justification (which is a matter of the scientific community). Justification and credibility are not unrelated, but they are sufficiently distinct to merit separate treatment. In section 2, I explore two strategies for improving the credibility of science. My argument is that they are unsatisfactory as they stand but that they can be elaborated into another proposal that I present in section 3. This proposal gives rise to the demand of a broad or evenhanded research agenda that includes a contrasting set of issues. In section 4, I extend this argument to the suitability of pluralism for increasing the epistemic credentials of scientific accounts. While these considerations boost the importance of pluralism for solving the credibility crisis, being stuck with a broad range of contrasting options is not a practically useful condition. In this respect, pluralism rather serves to exacerbate the credibility crisis. In section 5, I discuss options for diminishing the manifold of scientific responses in order to vindicate scientific knowledge as a source of practically relevant information. Bolstering the public credibility of science requires crafting an appropriate balance between opening up the spectrum of approaches (in order to improve the inclusiveness and reliability of the knowledge produced) and narrowing the range of options taken into consideration (so that coherent science-based advice is possible and science proves to be relevant in practical respect). This is intended to show in which sense and to which degree pluralism may be taken to respond to the problems of incompetence and one-sidedness and thus to contribute to restoring the epistemic reputation of science.

2. Possible Ways Out of the Crisis

If the politicization and commercialization is assumed to be the root of the predicament, abandoning such influences may be a way out. However,

given the social conditions under which research operates today, this recipe involves an operation at a very grand scale. It seems worthwhile to inquire whether more modest moves are suited to restore trustworthiness in the public arena.

The first suggestion for boosting the credibility of science is to build up and reinforce the independence of science that is typically said to require strengthening fundamental or epistemic research as a counterweight to application-oriented research that is dominated by market forces and political factions. Michael Polanyi is the classic source of the view that any attempt to intervene in science will impair research, the reason being that scientific progress is based on the non-coordinated reciprocal adjustment of scientists (Polanyi [1962] 2000, pp. 1–4). John Ziman gave the independence argument a different twist by claiming that the epistemic culture of open and unconstrained discussion, as it prevails in fundamental research, is indispensable for creating trust in science. By contrast, if research operates in the grip of material interests and under the pressure of short-term commercial or political goals, the scientific community will lose its non-partisan and disinterested attitude and be satisfied with superficial, biased, and insufficiently tested accounts (Ziman 2002; 2003). In the same vein, an initiative of medical doctors and pharmacists in Germany, called "MEZIS" as an acronym for "I pay for lunch myself," seeks to increase the distance between medical practice and industry. Again in Germany, Günter Stock, the former president of the Berlin-Brandenburg Academy of Sciences, launched a public campaign in 2014 for amplifying the independence of science from political forces (but not from economic companies).

The underlying idea is that operating detached from political and economic ambitions makes science an impartial arbiter that merits trust. This approach typically translates into the tenet that fundamental or epistemic research is able to counterbalance commercialized and politicized research. The former is characterized by two features: First, its institutional goal is to understand nature, not to produce some device intended to achieve some practical goal. By contrast, the institutional goal of practice-oriented research is related to utility. Corporate leaders judge the success of research efforts in terms of profits reaped. Institutional goals do not necessarily coincide with the motives of individual researchers, but they are important because they determine what counts as success or failure of a research endeavor (Stokes 1997, pp. 7–8; Carrier 2011, p. 14). Second, scientists themselves determine the agenda in epistemic research. This choice is made according to epistemic interest and expected solubility. Such research addresses areas where something can be expected to be found with a given theoretical or experimental approach. Epistemic research looks where the light is (Anderson 2001, p. 493; see Kuhn 1962, p. 164). In

contrast to this autonomous problem choice, the agenda in practice-oriented research is set by demands that are considered important in the extra-scientific world. The agenda is demand-driven in being, first, governed by considerations of utility and, second, imposed on science according to its urgency as assessed by social or political standards. Whether or not such problems are solvable in the first place is hardly taken into consideration. Examples are the identification of suitable measures for fighting climate change, the development of powerful electrical storage systems, or the discovery of therapies of Alzheimer's and Parkinson's disease.[1]

As a result, the independence approach considers social demands and the pressure of practice on science as the chief source of the epistemic decline of science that becomes manifest in incompetence and one-sidedness. The proposed solution is picking research problems according to epistemic interest and feasibility, which keeps social influences automatically at a distance. But the price to be paid is often the loss of relevance of science for concrete social problems. Epistemic research remains sometimes locked in the ivory tower.

The second approach to restoring the epistemic reputation of science is what I call counter-politicization, i.e., combating illegitimate external impacts on science by bringing in justified sociopolitical influences. The idea is that the origin of the credibility crisis of science lies with the failure of research to address real-life problems. Science indulges in self-created issues that do not reach the world outside of university labs. Instead, science needs to focus on practical problems. Fundamental research seldom produces significant practical progress but attracts the lion's share of the resources. Redirecting these resources to projects that immediately mitigate human suffering would be beneficial to both the epistemic authority of science and to humankind (Kourany 2003; 2010, chaps. 1, 5; Cartwright 2006). According to this approach of counter-politicization, political influences on the research agenda may serve to enhance the utility of science, and it is this increased utility that helps overcome the credibility crisis of science.

A large-scale political endeavor to foster counter-politicization is the demand for "responsible research and innovation" which is, among other

1. A lot of criticism has been advanced against the distinction between epistemic and practice-oriented research. However, such objections focus on the impossibility to categorize a given research project as either epistemic or application-driven. Yet, the conceptual separation does not rule out that a given research project serves both ends simultaneously (Stokes 1997 pp. 12–7). It is compatible with this distinction that there are no purely epistemic projects (Carrier 2013, p. 2548). If the distinction is granted as a conceptual instrument, it allows us to pursue questions as to which kinds of research are subject to a decline in public reputation and which kinds could help re-establish credibility.

things, part of the EU research framework "Horizon 2020."[2] An important idea linked to this endeavor is that responsible research and innovation should be responsive to social challenges which can be achieved by public participation or by acting on behalf of the public in applying the so-called precautionary principle. Such research demands the willingness of scientists to adjust their projects in response to stakeholder intervention, social values, and changing circumstances (Stilgoe et al. 2013, pp. 1572–74; von Schomberg 2013, pp. 63–5).

In the philosophical context, this approach of counter-politicization has been elaborated and prominently pursued by Kitcher. His goal is to democratize science through systematic participation of the public in setting up the research agenda. Science regains its epistemic authority if it visibly commits itself to the betterment of the human condition. And this commitment becomes visible if the public draws up the research agenda itself. This public influence makes it perspicuous that science has something to contribute to improving human life. In Kitcher's well-ordered science, representatives of the public do not merely give advice but make decisions about research topics. There is no place for autonomous problem choice by scientists (Kitcher 2004; 2011, pp. 117, 129–30, 217).

The message of this counter-politicization approach can be reconstructed such that incompetence is avoided by keeping all merely partial sociopolitical interests at bay that distort a trustworthy picture, while one-sidedness is not eliminated but rather funneled into publicly approved channels. Focusing research on demands ratified by the people is a legitimate sort of one-sidedness (Intemann 2015, p. 218). Whatever the general credentials of this approach are, the critical question from a philosophy-of-science perspective is whether such demand-driven research, in which the research agenda is determined by social choice, is the best way to maximize public benefit.

The traditional objection to this approach is the claim that discoveries cannot be anticipated and creativity cannot be fenced. It is impossible to guide research toward specific ends; any attempt to do so will only block scientific progress (Polanyi [1962] 2000, pp. 3, 10, 14). This is true to some extent, but the objection is often overdrawn (Wilholt 2012, pp. 107–10). In fact, there are many examples of successfully planned research. State authorities or foundations managed to fruitfully get research programs underway that produced innovative environmental protection technologies (such as catalytic converters, or flue gas desulfurization).

2. (http://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation)

Likewise, industrial research accomplished demanding research goals. Giant magnetoresistance, a physical effect that underlies most hard disks presently in use, was systematically sought (in analogy to a different, already known effect), successfully identified in 1988 and subsequently translated into a technology (Wilholt 2006). Likewise, the development of the CD was based on advanced research in optical storage technology and was a response to an assumed demand (de Vries 2011, pp. 61–2). In some instances, research can be planned successfully, and this is why the option of demand-driven research exists.

A difficulty arises, though, if research is committed to exclusively following this demand-driven mode. If the epistemic authority of science is supposed to be re-established by tying the research agenda to public choice, then the demand-driven way is the only way to go. The trouble is that beneficial research outcome cannot be produced at will. Not infrequently, demand-driven research fails or yields unexpected results. Failed demand-driven projects are the development of a vaccine against HIV or finding ways to successfully combat antibiotic resistance in bacteria. Both endeavors were surprising failures; the odds of success had been expected to be good in advance. Similarly, more than a decade ago, leading neuroscientists envisaged the advent of effective medication against Alzheimer's and Parkinson's disease within ten years (Monyer et al. 2004, p. 36). Nothing of this sort is in the offing yet. Conversely, many achievements go back to chance discoveries. Medical research provides lots of examples of such unexpected presents. Administrating beta-blockers against cardiac insufficiency, employing lithium against bipolar disorders, and the present use of Viagra are all due to pleasant surprises. Nobody had anticipated these options. It is often impossible to discern in advance whether a research endeavor will prove useful eventually.

As a result, the chief difficulty of a comprehensively demand-driven research agenda is that research goals stated in advance can often not be reached. Such goals can be attained under favorable conditions, but we cannot rely on such success. This uncertainty makes it risky to seek to ascertain the credibility of science by counting on the success of democratically planned research projects. As a result, pursuing the counter-politicization approach can easily backfire and inadvertently further undermine the epistemic reputation of science.

3. Benefits of a Pluralist Research Agenda

The preceding considerations suggest that, in the judgment of the key figures of the debate, there are two ways to strengthen the credibility of science among the public: increasing its relevance and reliability. Trustworthy research addresses problems that are considered important in the

eyes of the public (i.e., relevant) and produces results that are well confirmed (i.e., reliable). The latter virtue chiefly addresses the charge of incompetence and is emphasized by the independence approach. The former merit mainly responds to the objection of bias and is stressed by the counter-politicization account. People are assumed to judge science by the viability of its contributions to practical problems and by the perceived dependability of its findings. The claim I seek to elaborate in the second half of this paper is that pluralism plays an ambivalent role in this endeavor. I argue in sections 3 and 4 that promoting pluralism is a way to establish both relevance and reliability, but go on to point out in section 5 the flipside of pluralism when it comes to guiding action. Pluralism is beneficial in epistemic respect but detrimental in pragmatic respect.

I begin by exploring the influence of pluralism on relevance. A pluralist approach to crafting the research agenda means broadening the agenda. This, in turn, augments the prospects of including elements that are taken to be significant by a wider audience. Various indications support the view that the credibility crisis of science at the interface with society is at least partially due to the impression of parts of the public that research does not sufficiently take up their interests and concerns. In fact, the complaint of one-sidedness is widely shared with regard to medical drug research. Pharmaceutical companies exclusively seek treatment options that are susceptible to patenting. This leaves lifestyle effects, such as diet and exercise, out of consideration (Brown 2008, pp. 197–9). Other non-patentable approaches, such as using bacteriophages for fighting inflammation, are also left unexplored by privately financed research. Such a skewed research agenda prompts the public attitude that medical research is mostly profit-driven and, as a result, fails to respond to urgent practical questions. Given the widespread public unease about for-profit thinking in medicine, broadening the research agenda in this way can be expected to enhance the trustworthiness of science among the public.

There is more specific evidence supporting this expectation. A glaring example of a lack of trust is vaccine skepticism and the anti-vaccination movement. A significant hesitancy is observed among parents as regards the vaccination of their children. This attitude is usually attributed to egregious knowledge deficits among the parents and a general attitude of hostility toward science. The often-quoted evidence is that the allegation of a causal link between measles-mumps-rubella vaccine and autism still lingers on in the relevant circles, although this relationship has been disproven and universally abandoned decades ago. However, as Maya Goldenberg pointed out, parents' reluctance is not always the result of general skepticism about science, but rather due to their impression that the questions most pressing to them were missing on the standard agenda. Research as usual is satisfied

with demonstrating that vaccination is beneficial to public health: it reduces the incidence of the relevant disease drastically. It is granted that side effects occur in rare cases and that they may even be severe, but on the whole, benefit largely outweighs harm. However, parents are not so much interested in the population level; they rather focus on their individual child. More specifically, they want to see it ruled out that their child is among those rare cases in which damage occurs. Consequently, they ask for research on those factors that predispose children to show such side effects. To date, such research is missing (Goldenberg 2016).

A study on lay participation in implementing hydraulic fracturing technologies, commonly known as fracking, in Northern England points in the same direction. The participation scheme was guided by the idea that the local community would receive information about the benefits of fracking and the effective risk management procedure in place and would welcome the technology in this light. However, the response turned out to be different. The participants criticized that the whole design was structured in a restricted and one-sided fashion and demanded a much broader deliberative procedure around various innovation choices and the social desirability of fracking (Williams et al. 2017, p. 98–9). It is true that this example concerns technology implementation rather than research options in a narrow sense. But the common question is which scientific or technological innovations are suitable and advantageous to the public. And again, the upshot is that the public went away disappointed because the agenda was not set up in a sufficiently pluralistic way.

Accordingly, it is the omission of questions deemed relevant by parts of the wider audience that is likely to prompt a marked lack of trust in science. It is plausible to conclude that enlarging the range of research topics and addressing such missing questions would diminish the impression of one-sidedness of research and thus would contribute to fostering public trust. For gaining public trust in this respect, taking serious effort would certainly be as important as an accomplished solution. Hugh Lacey has introduced the notions of "neutrality," "inclusiveness," and "evenhandedness" to designate the proposition that science should equally serve a variety of different kinds of research objectives. In particular, scientific research should not privilege some value-outlooks or special interests at the expense of others. That is, research projects are legitimately guided by non-epistemic goals and heuristics, but on the condition that the ensuing research commitments are distributed even-handedly across the range of "viable" social demands. For instance, commercial interests should be balanced by values such as empowerment of poor people and indigenous cultures, and environmental sustainability (Lacey 2013, pp. 79, 81–2). Accordingly, bias can be avoided by broadening the research agenda. Such

evenhandedness is produced by pluralism and is supposed to retain or re-establish the relevance of science for marginalized segments of society. The expectation is that evenhandedness is suited to bolster public trust in science.

The sort of pluralism hitherto addressed refers to a wide range of issues taken up in a research field. This pluralism can be tied up with the positions discussed in section 2. An evenhanded research agenda may then also mean a balance among three major branches of science. First, Kitcher's well-ordered science addresses research items that the public assumes to be in its own well-considered interest. However, as argued before, such an exclusively demand-driven strategy seems to be too risky and its success too unpredictable to serve as the chief plan for regaining public trust. Rather, Kitcher's procedure might be better suited to govern a particular branch of research, namely, "research in the public interest" (Krimsky 2003, chaps. 11, 13). In this type of endeavor, research topics are chosen according to their intended effects upon those affected by the research results (Carrier 2011, pp. 19, 28). Philanthropic initiatives in medical research represent such research in the public interest. At present, this area is dominated by private initiatives of individuals or foundations. Likewise, research on climate change is an effort of high practical relevance that neither grew out of epistemic research nor was sponsored by economic companies. Research in the public interest stakes out the area in which Kitcher's scheme of well-ordered science might be legitimately put into practice. In other words, the project of counter-politicization is a promising and convincing approach if it is interpreted as a proposal for supplying a more coherent structure to this area of science in the public interest.

Second, fundamental or epistemic research, as championed by the independence approach, also represents a legitimate mode of selecting research topics. Judged by the standard of evenhandedness, the reason for its legitimacy is that such research underpins more concrete, demand-driven projects. On some occasions, practice-oriented research needs to return to the drawing board and resort to epistemic endeavors in order to be successful. The early attempts in gene therapy came to grief profoundly and practical success only emerged after a period of fundamental reorientation (Lewis 2014). Thus, epistemic research is sometimes vital for making practice-oriented research sustainable. Third, likewise judged by the standard of inclusiveness, market-driven practice-oriented research merits consideration as well. Such research is also demand-driven in that it proceeds from expected human needs and interests. Only what is liked and bought by many is successful on the market (Carrier 2011, pp. 17–8). Industrial research serves many practical interests well and should not be stifled by one-sidedly privileging research exhibiting a universal appeal.

Yet the downside is that each such branch tends to neglect a variety of questions that are important from a more inclusive perspective. This is why a balance or pluralism needs to be retained among all three branches. The independence approach champions epistemic research and this is all right as far as it goes. It serves to detach research from social forces, but it thereby also removes science from the concerns of the people. The merit of counter-politicization is to link up research with these concerns and to feature science in the public interest. However, exclusively stressing this approach overlooks the value of autonomous problem choice by scientists and the advantages of market-driven research. The latter also takes up needs, interests, and concerns of the people in producing useful novelties. Many welcome its products, such as high-density hard disks or flat screens.[3] Such research may also contribute to making science more acceptable and more credible among a lay audience. As a result, epistemic research, market-driven research, and science in the public interest are all legitimate. The really troubling feature is that one of these branches gains a monopoly for acceptable research, as market-driven research virtually has in present-day pharmaceutical research, or as Kitcher demands for well-ordered science. Rather, these three branches should be considered complementary. They contribute all three to the evenhandedness of the research agenda.

A salient question at this juncture is what is the right balance or distribution of resources among the three branches. Rather than offering a comprehensive scheme for estimating the most beneficial ratio, I propose to proceed from perceived imbalances. Maladjustments are often relatively easily diagnosed in a consensual way. For instance, it is almost part of conventional wisdom that privately sponsored pharmaceutical research is in need of a public counterweight. The bias reported from this area has reached epic dimensions.[4] Similarly, demand-driven research on nuclear

3. The usefulness of market-driven research is contentious. An objection raised by a reviewer for this journal is that industrial research of this kind only benefits minorities, i.e., customers in well-to-do countries, and does not respond to social needs in a more substantial sense. However, the impact of market-driven research is difficult to anticipate. Unexpected spillovers may occur. Cell phones were developed for consumers in rich countries, but they had a tremendous favorable impact on Africa. The technology allowed poor African countries to skip expensive ground-networks and to provide affordable and widely accessible telecommunication options (Pew Research Center 2015, p. 7). Further, most innovations merely serve minorities. Each new medical drug targets only a small set of people. Requiring of acceptable novelties that they address the needs of most of the people at a global scale leaves us with a tiny fraction of advances and could slow down the pace of innovation considerably.

4. Krimsky 2003, pp. 147–52; Brown 2008; 2011. See also the references regarding biased clinical trials given in section 1.

fusion had run into an impasse in the 1980s since plasma turbulence was much more difficult to control than anticipated. As a result, scientists decided to step back and to approach the matter with a long-term perspective in mind. The upshot was the creation of plasma science as an epistemic discipline. This shift from demand-driven to epistemic research was supposed to amend and rectify the shortcomings produced by an overhasty commitment to practical benefit (Plasma Science Committee 1995; Weingart, Carrier and Krohn 2007, chaps. 1, 3; see also the gene therapy example mentioned before). Finally, students of quantum entanglement were happy when prospects of application emerged with respect to their supposedly purely epistemic field. Quantum encryption and quantum computation relieved the field from its former otherworldly reputation. The upshot is that by responding to a perceived imbalance, a proper equilibrium among the three branches at hand can be restored. The present article can be viewed as an attempt to make the need for striking such a balance more conspicuous and as a plea for making such shifts and corrections in a more explicit, reasoned, and elaborate way. Such a balance seldom arises by itself but rather needs to be produced by deliberate effort. All three branches are part of present-day research, to be sure, but many specific research areas suffer from a disequilibrium that calls for being redressed. One of the goals of this paper is to highlight the need for active intervention in order to secure a sufficient amount of plurality and to restore evenhandedness (see Carrier 2011, pp. 28–9).

The upshot is that, regarding the research agenda, a two-fold pluralism seems apt to promote the relevance of research for the general public. This pluralism concerns setting the research agenda in an evenhanded way by taking up public interests and concerns broadly, and it extends to the three branches of science. This latter sort of pluralism connects the general call for an inclusive agenda with the proposals of the independence and the counter-politicization approach for overcoming the credibility crisis of science.

4. Pluralism as a Pathway to Reliable Knowledge

In addition to being biased scientific experts are suspected of being incompetent, that is, giving ill-founded recommendations. In this section I address the role of pluralism in articulating reliable answers to problems of a practical nature. This role is ambivalent. The first thing is that social epistemology emphasizes the importance of a variety of competing approaches for arriving at well-confirmed conclusions. The social notion of objectivity is centered on critical debate and reciprocal control. A multiplicity of approaches serves this critical spirit best and is suited to neutralize the impact of the blind spots from which each individual suffers. The increased level of

criticism, as it emerges in a pluralist setting, can be taken to intensify the process of examination and strengthen the well-testedness of those approaches that survive the process. Thus, strife and antagonism within the scientific community is among the core features of scientific method. Pluralist science is better-tested and more reliable science (Popper 1966, pp. 412–13; Longino 1990, pp. 66–80; Carrier 2013, pp. 2548–49, 2558).

In fact, this is how research tends to approach demanding challenges. When difficult new issues need to be tackled, the research community is likely to split up into a variety of competing approaches. Consider the competition between string theory and quantum loop gravity or between a cell-based and a holistic understanding of cancer (Carrier and Finzer 2011) in present-day epistemic research. The epistemic rationale is to attack a problem from different angles and thereby to increase the odds of success (Kitcher 1993, chap. 8). When a deeper understanding is reached, this pluralism usually gives way to consensus. The customary account of this transition from pluralism to consensus says that severe pluralist testing often reveals that a certain approach is superior in all relevant respects so that a unanimously accepted standard account surfaces under such circumstances. After some time of evolution of a spectrum of contrasting theories, a variety of different indicators of methodological quality will tend to clearly distinguish one of the rival accounts (Kuhn 1969, pp. 204–6; McMullin 1987, p. 67; Kitcher 2000, pp. 26–7, 35). A multiplicity of approaches at the forefront of research is epistemically beneficial and such a manifold emerges naturally since the competing approaches have different profiles of virtues and vices and cannot be judged unambiguously for this reason (Kuhn 1977). After some time, plurality gives way to a greater unanimity of judgment since typically one of the alternative approaches achieves a superior ranking on most or all quality standards.

It is worth emphasizing that the accounts under consideration regarding confirmation and reliability are rivals and conflict with one another, whereas the approaches discussed with regard to the even-handedness of the research agenda are complementary and do not converge toward consensus. Actually, in this latter respect, sustained pluralism is the desirable way to go. The import of a study on the effect of a medical drug is delimited more clearly if it is contrasted with a study on lifestyle effects. The relevance of the former study is increased by delineating its domain through another study conducted from a different angle. However, as to confirmation and reliability, pluralism extends to contrasting, incompatible approaches. In this regard, the account elaborated here favors transient pluralism: pluralism is welcomed as a means to the epistemic end of reaching a justified consensus eventually. Pluralism leads to stricter tests and undermines itself by prompting superior accounts. Such an unforced

consensus, produced by the power of experience and argument, is the traditional hallmark of scientific knowledge.

The social notion of objectivity and the pluralist approach going along with it provides the prospect of upholding demanding methodological standards even of no neutral scientists are available. The Baconian notion of objectivity requires dropping all non-epistemic motives and proceeding in a detached, open-minded and unprejudiced fashion (Bacon [1620] 1863, Bk. I, § 37–65, 68). While it is certainly true that Baconian standards can be approached to some degree in some fields, it seems also clear that such neutrality is hard to achieve when stakes are high and interests are strong. Worldly ambitions and social values are likely to interfere with the neutrality and quality of inquiry. Financial conflicts of interest can be expected to lead to shoddy studies that contribute to damaging the credibility of science (Elliott 2014). Around 2000, editors of medical journals adopted an anti-corruption policy to the effect that meta-reviews about the safety and effectiveness of medical drugs were required to be done exclusively by authors without vested interests in any one of the drugs under review. This policy failed because in many cases no such authors could be identified (Brown 2008, p. 194). Scientists who were sufficiently familiar with a pharmaceutical area also had stakes in this area. Expertise and vested interest formed a faithful if unholy couple. This is where Baconian objectivity has shifted out of reach.

However, the social and pluralist notion of objectivity can still work under such circumstances, the reason being that distributing the epistemic risk among various factions by dividing up a research community and multiplying forces is a strategy of general benefit under uncertainty. As a result, pluralism and controversy is also found in demand-driven research where future financial gains loom large. In medicine, Alzheimer's disease is subject to divergent judgments. One camp suggests beta-amyloid plaques as the chief culprit; a rival camp casts the villain role with tau protein tangles. The causal story is reversed in both camps. What is considered the cause in one research community, is assumed to be the effect in the rival community. A third party claims that the crucial damage is done by energy shortage in the brain and that this penury produces the physiological features that the competing approaches take to be causes. In fact, as this third approach suggests, Alzheimer's is a sort of diabetes of the brain. A fourth faction features prions, i.e., infectious agents composed of misfolded proteins. In this view, the disease is driven by an infection-like spread of such protein aggregates in the brain.

Pluralism is epistemically beneficial even if the studies involved are biased in themselves. This means that an approach that addresses the matter from a specific narrow angle can be offset by a study that is similarly narrow, albeit in a different respect. For instance, in the early 2000s,

scientists articulated worries to the effect that the anti-clotting efficacy of aspirin would decrease over the years and thereby stirred up a controversy. Some years later, a journalist revealed that a company producing alternative anti-clotting agents had launched the whole debate about this assumed habituation effect. Conversely, some of the principal scientists who opposed the alleged drop in effectiveness were funded by the leading aspirin manufacturer (Wise 2011, p. 288). I take this episode as an indication that competing economic interests and opposing value attitudes are able to exert a corrective influence. They can prompt reciprocal criticism that serves to redress the balance and to produce a better confirmed account eventually.[5]

Along these lines, a lack of pluralism is sometimes held responsible for low epistemic quality. In 2012, Gilles-Éric Séralini published a study in which he reported the emergence of cancer in rats nourished by glyphosate-tolerant genetically modified corn. The study was heavily criticized in methodological respects, and its results are highly contested (Carrier forthcoming). The crucial item in the present context is that in an article published in the periodical *Le Monde* in 2012, a large number of French scientists blamed the lack of dependable results in this area to the absence of pluralism. They argued that it would have been imperative to assign the preceding studies of the agent substance, as conducted by the relevant industry, to a variety of researchers in the first place (Andalo et al. 2012). Accordingly, in the judgment of the pertinent scientific community, studies that approach the matter from different directions would have produced a more reliable outcome.

Such pluralism is typically followed by an emerging consensus, but this transition is not yet complete in ongoing research. While the process typically remains hidden from the public in epistemic research, the opposition of diverse approaches becomes conspicuous if the research proceeds in the social arena. In cases of research on urgent problems, the struggle between the antagonists proceeds in the limelight (Collins and Evans 2002, pp. 246–8; Carrier 2013, p. 2562). The pattern agrees in epistemic and practically relevant research at the interface to society: a pluralistic phase of antagonism is followed by concurrence. The difference is that in the latter case, this antagonism and the reciprocal criticism going along with it unfolds right on open stage before the public eye. This is where the downside of pluralism becomes visible. A wide range of competing hypotheses is

5. However, social notions such as reciprocal criticism cannot guarantee in themselves that demanding epistemic standards are satisfied. What is necessary in addition is an individual commitment to rational argument and empirical evidence. An "epistemic attitude" of a sufficient number of individual scientists is needed as well (Carrier 2013, pp. 2563–64; López Cerezo 2015, pp. 314–16).

less than convincing as a guide to matters of practical importance. I will address this question in section 5, but this multiplicity also casts new light on the predicament of science in the social arena.

Pressing practical problems can often not be solved by linking them up with the system of knowledge. In such cases, science needs to face complexity and uncertainty, and actually runs the risk of being overburdened. Take the transition of national electricity systems from fossil sources to renewable energy. Experts are at a loss in some respect about which measures are to be taken for this purpose. Is extending the electric grid the way to go or is it better to support the development of efficient and powerful small-scale storage systems? There are various technical processes in the pipeline for stepping up the local storage capacity, and it might well become feasible to save green electricity locally for periods without wind and sunlight. No expensive large-scale electric grids would be necessary. But nobody knows at present whether this guess will be correct. Science operating at the interface with politics is faced with complex challenges and a large amount of uncertainty. As a result, the ensuing diversity of judgment is a usual response to complexity and uncertainty; it is not a deficiency of politicized research. As a result, the expert's dilemma appears in a more favorable light. The failure of science in some areas of practical importance is real; regarding some intricacies of the life world, the limits of scientific knowledge are reached. Yet, rather than indicating the corruption of science through its politicization, this failure shows how hard it is to move from scientific generalizations to complex challenges of the life world. To sum up, conclusions reached through confronting antagonistic approaches with each other are likely to have run through a test procedure of pronounced severity and tend to be more reliable. This is how pluralism in science may contribute to overcoming the perception of incompetence.

5. The Harm Done by Pluralism to Taking Action

The preceding considerations primarily concerned the positive impact of reciprocal censure and mutual control on the epistemic credentials of scientific assumptions. As a rule, pluralist science is more severely tested and more reliable—provided that sufficient time can be granted to enable consensus formation. However, it is one thing to say that pluralism serves to step up the justification of research results; it is a different thing to assume that this improvement is recognized by the public and thereby enhances credibility. To be sure, some complaints about incompetence might dissolve if the public comes to understand the importance of controversy for examining knowledge claims and to appreciate the partial nature of many such claims. Still, appreciating pluralism goes only halfway

in making science appear more trustworthy to the public. After all, in order for science to become relevant for practical issues, it needs to entail clear messages. A range of contradicting suggestions might not appear overly useful to a wider audience.

What is characteristic of science in the social arena are the uncertainty and the tentative nature of many scientific responses as well as the time-pressure under which they are developed. It is of no avail to wait until the dust of controversy has settled. As a result, the plurality of antagonistic approaches is exposed to the general public (see section 4) and is taken as indicating incompetence and unreliability. The question is, accordingly, how to deal with this downside of pluralism for science in the social arena. One suggestion is that politicians or agents in general need to learn how to cope with conflicting advice from science and to pick for themselves which advice they consider appropriate (de Melo-Martín and Intemann 2014, pp. 606–7). This may be necessary in some cases, but issued as a general recommendation it means giving up on the challenge of science-based advice. Another suggestion is to pick coherent chunks of knowledge as the basis of recommending action (Chang 2012, pp. 265–6). However, in cases of practical relevance, the controversial issues usually extend well into the relevant parts of knowledge.

Faced with concrete challenges, scientists cannot afford to wait until one of the relevant approaches has the edge over its competitors. Rather, the spectrum of approaches needs to be diminished at a quicker pace. I suggest two sorts of consideration: epistemic robustness drops factors and accounts that have no immediate relevance for the judgment at hand, social robustness leaves out all choices that hardly stand a chance of being implemented because of opposing interests and value-attitudes in the population.

A promising strategy for arriving at widely shared conclusions is "epistemic robustness" or "coarse-graining": the gist of an analysis or recommendation remains unchanged albeit the underlying causal influences and factual conditions vary to some degree. In practical matters it is often a widely accepted strategy to "be on the safe side" and to recommend threshold values that remain well below the expected emergence of harmful effects. Thus, uncertainty about the precise nature and amount of a distortion does not necessarily hurt. The Intergovernmental Panel on Climate Change (IPCC) also practices this strategy by admitting large error bars. If epistemic robustness is heeded, ignorance of the precise conditions matter less in practical respect (Carrier 2010; Carrier and Krohn 2016). If large wiggle room is granted to relevant projections and predictions, consensus is more likely to ensue. This means emulating the process of convergence in fundamental research by blurring the relevant results. The challenge is to put these results in a way that they unambiguously point in certain practically relevant

directions. A variant of this strategy involves coarse-graining the accounts on offer (rather than the details of the influences at hand). The idea is to distill a conclusion from the plurality of approaches that is suggested or entailed by most of these approaches. One such option is to select measures that need to be taken anyway. For instance, moving to green electricity requires improved power storage systems in any event, and for coping with climate change, some adjustment to sea-level rise will be indispensable at any rate.

Second, invoking social values may contribute to reducing the range of accounts scientists need to take into consideration. The odds increase for getting a conclusion accepted by politics and the public if this conclusion is compatible with value-attitudes as they prevail in society. "Social robustness" in the sense of compatibility with widespread value attitudes in society may be influential on the content of the recommendations (Carrier 2010; Carrier and Krohn 2016). Faced with controversial evaluations, scientists may attempt to squeeze a lesson out of the multiplicity of scientific accounts that appears endorsable to many social factions. An example of such socially robust advice is setting strict threshold values for suspicious chemicals even without unambiguous evidence for their harmfulness. Being cautious contributes to pacifying strife and demonstrates the willingness to meet the critics halfway. Further, if the population is in favor of green energy, uncertainties regarding climate effects of coal-fired power plants need not be taken into consideration (Carrier 2010; Droste-Franke et al. 2015, pp. 13, 38–51; Carrier and Krohn 2016). Further, scientists in elaborating their recommendations may include the social consequences of their suggestions, or, more precisely, the socio-economic costs of being wrong, and thereby drop many such suggestions without assessing painstakingly their epistemic credentials (Douglas 2000; 2009).

These two strategies appear to be suited to reduce pluralism in practice driven research.[6] It goes without saying that the approaches that become subject of this evaluation of practical relevance need to pass some minimum threshold regarding reliability. Yet, the auxiliary criteria brought to bear in this second round of evaluation do not latch onto their epistemic credentials but rather focus on their practical virtues. Consequently, such pragmatic auxiliary considerations can be trumped by epistemic superiority. It is true, social robustness and the attempt to remain within the framework of publicly accepted values discourages bold expert recommendations that call into question current commitments. As one of the referees

6. An additional strategy is identifying and abandoning "agnotological studies" such as those revealed by Proctor and by Oreskes and Conway (see section 1). Such studies are flawed in methodological respect and fail to represent a serious epistemic endeavor (Carrier forthcoming).

for this journal objected, social robustness tends to favor the status quo and short-term goals over long-term goals. Point granted. However, audacious expert advice that envisions new horizons should be supported epistemically and not draw on auxiliary standards alone.[7]

6. Conclusion

I explore options of how the public credibility of science can be preserved even though science is part of the public arena and subject to partisan political and economic forces. This question is addressed by stressing the benefits of a broader range of research problems and a variety of competing approaches. The inclusiveness induced by this topical expansion serves to constrain the one-sidedness of the research agenda and thus to promote relevance; and the reciprocal control produced by diversity within the scientific community is apt to improve epistemic support and thus to combat incompetence. This applies to conceptual pluralism within each research field, but also to pluralism among the branches of science. Strengthening the pluralism within and among these branches is a way of making research more relevant and reliable.

While it is important to realize that opening up the conceptual space is epistemically beneficial, it is also true that science, as a guide to practical matters needs to cut pluralism. The procedure employed in epistemic research is pursuing controversial avenues until one of the relevant approaches manages to become superior in all relevant respects. Yet, such a smooth resolution of controversies cannot be expected within the narrow time constraints in the practical realm. Since pluralism is perceived as a lack of knowledge and proficiency among the wider public, pluralism is likely to sap public credibility. In practical matters, the urgency of the issues at hand requires reducing the range of options. This reduction is the complementary step to broadening the scope; both moves are called for in order to combat the appearance of incompetence.

Pluralism can be cut back for practical matters by appeal to epistemic and social robustness. Epistemic robustness focuses on invariant features or consequences widely shared among competing scientific accounts. Social robustness emphasizes scientific accounts that fit into the pertinent nonepistemic value system. It leaves out all choices that conflict with powerful interests and values and can be expected to fail in the political process anyway. Thus, I suggest addressing the credibility crisis of science by means

7. In contrast to Wilholt (2013, p. 250), my proposal does not bind the trustworthiness of science-based advice to shared relevant evaluations between researchers and the public. Scientists can contradict public expectations without compromising their trustworthiness if they are backed by epistemic reasons.

of a carefully crafted balance between opening up the conceptual space and diminishing the range of options. Pluralism is part of the solution to the credibility crisis in promoting evenhandedness and well-testedness, i.e., relevance and reliability, but it is also part of the problem by preventing the emergence of unambiguous practical suggestions. In order for science to be a suitable guide for practice, the leeway of options needs to be narrowed and pluralism be curbed. This can be achieved by appeal to auxiliary criteria that do not focus on how precisely such suggestions fare empirically (assuming that they pass a minimum threshold of epistemic quality), but their appropriateness in practical respect.

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