STATISTICS, SCIENCE AND PUBLIC POLICY

RECOMMENDATIONS FOR GOVERNMENT AND THE SCIENTIFIC COMMUNITY

Review of Conferences on
Statistics, Science and Public Policy
Held at Herstmonceux Castle, Hailsham, U.K. and at
Queen's University, Kingston, Ontario, Canada.

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I was very honoured to be asked by Dr. Agnes Herzberg to provide a foreword to this summary.. For many years, I have admired, as well as participated, in the annual Conference on Statistics, Science and Public Policy held at Herstmonceux Castle in the United Kingdom and at Queen's University in Kingston, Ontario. I also had the great pleasure of addressing the conference in 2001 on the topic "The Canadian Parliamentary System and Scientific Advice".

These invaluable conferences bring together outstanding individuals from a variety of professional fields to address topics of interest, and their importance, both to speakers and to participants, cannot be underestimated. In addition to the valuable insights that inevitably occur when talented people come together to discuss interesting ideas, the professional and personal relationships that are forged during these meetings ensure that the aims of the conference, namely, the furthering of knowledge, trust and co-operation in the spheres of government and science, are met and surpassed.

This summary is excellent and a tangible example of that co-operation, and it will, I believe, provide the reader with an admirable overview of the topics covered during the various conferences, the discussions that occurred and some of the ideas that emerged from those exchanges. It will serve as a valuable tool to those seeking to learn more about the interdependence of science and public policy.

Peter Milliken, M.P.
Speaker of the House of Commons

Executive Summary

Science, including statistics, is fundamental to the society in which we live. It forms the bedrock of our economy and is an essential part of our intellectual heritage. Without science we would be materially and culturally poorer.

Effective public policy depends on good science and good scientists, but in practice scientists, including statisticians, play only a limited role in the formulation of public policy.

A casual ad hoc *approach is an inefficient and incomplete way to deal with the range of scientific issues of national and international interest.*

Each nation should implement a mechanism to deal specifically with scientific issues at the highest level. Particulars will differ according to each nation's interests, resources and political organization, but each such plan will need to address the issues raised here.

Science policy could be better informed nationally and internationally if:

1. Comprehensive strategies for scientific advice are implemented to include:
   (a) The coherent organization of scientific advice for government, within individual departments and across departments.
   (b) A strategy for the organization of advice from scientists outside government.
   (c) Fitting these streams of advice into policy-making structures.

2. Guidelines and standards are implemented which
   (a) Guide sound use of scientific advice (e.g., by public servants and officials).
   (b) Prevent conflicts of interest from undermining the objectivity and credibility of the advice.

3. The public trust in science is engaged and enhanced by:
   (a) Developing public understanding of the fundamentals of risk and uncertainty.
   (b) Clearly separating fact from judgement in public discourse.
   (c) New models of interaction between science and society.

4. Educational initiatives are undertaken which:
   (a) Ensure, *via* the school curriculum, that the general public understands what scientists do, why as well as how they do it.

   (b) Ensure that all graduate scientists have a broad, liberal education that enables them to understand how government policy-making works, and to communicate clearly and concisely with government and the public.

(c) Fundamentally reform current methods of evaluating teaching and research at universities in order that hey do not militate against this broader view.

5. Government, professional bodies and academic institutions encourage scientists to undertake a critical role in developing strategy, plans and evaluations; and to participate fully in their formulation.

6. Issues treated by decision-makers as scientific frequently involve moral, social and ethical dimensions. These must be recognized and dealt with by all concerned as an integral part of the scientific problem.

Scientific contribution to public policy faces non-negligible systemic challenges. These include:

1. Communication between scientists and government
   - (a) Two cultures are at work. Government and scientists have different world views and different expectations about the nature and goals of collaboration. Communication is difficult, and relationships can be strained.
   - (b) Scientists often fail to understand the way government works and how their advice fits into overall policy.
   - (c) Scientists are not trained to put their advice into simple, concise terms which are easily understood by non-specialists.
   - (d) Scientists do not always understand how to obtain access to decision-makers. Decision-makers are unclear as to when and how scientists should be approached, and which among them are to be consulted.
   - (e) Government officials often do not understand when science can be helpful, and sometimes do not want advice that runs contrary to political interests.

2. Public understanding of science is patchy.
   - (a) Public appreciation of science and risk is poor, leading to poor judgements by both the general public and the politicians who represent them.
   - (b) Poor appreciation of scientific uncertainty and method can allow pseudo-science to capture public attention.

3. Educational challenges.
   - (a) Educational systems frequently exaggerate the differences between science and the humanities through early specialization and lack of attention to a broader education including the tertiary and post-graduate level. This lack of attention includes, but is not limited to, the liberal aspects of a scientific education.
   - (b) Short-term horizons of political and commercial interests conflict with the long-term interests of a broad education and fundamental research.
   - (c) The pressure for measurable results in both scientific teaching and research is proving counterproductive and costly.

(d) The role that universities might play in providing a broad, general education for all students is being undermined by government's exaggerated attention to immediate economic outputs.

Statistics, Science and Public Policy

INTRODUCTION

Each year, since 1996, an international group of distinguished scientists, academics including university vice-chancellors, experienced science journalists, senior civil servants and elected politicians has met at Herstmonceux Castle in Sussex to discuss the role of science and statistics in society.

The central conclusion is simple. Despite the profound significance of science and statistics for public policy, scientists and statisticians play only a limited role in the policy process. This report summarizes the reasons why and presents recommendations for action by government and, crucially, by scientists themselves.

The conferences are inspired by the work of the late Dr. Gerhard Herberg, Nobel Laureate, who spent his life in the pursuit of science but also found time for the arts, especially music. He worked on behalf of dissidents and campaigned vigorously for the funding of pure science by governments, arguing that society should maintain a high standard in both science and the arts. Survival should not be society's only goal. He held that all citizens needed to consider "the works of art, literature, and basic science as not merely the icing on the cake but as the essence of human existence. Without that, to quote C.P. Snow, "some of the major hopes, the major glories of the human race will rapidly disappear" [23].

SCIENCE AND STATISTICS IN TODAY'S SOCIETY

Science

Science is an outstanding cultural achievement which, as with great art and literature, is an essential part of our heritage [17]. In accepting experiment, evidence and reason as the final arbiters of knowledge, science has given us a way of looking at the world that is unique in human history [20, 37].

Science has weeping social and economic consequences. Society depends on science and science-based technologies for our material welfare and economic prosperity. The ability to address some of the world's most pressing problems – poverty, disease, environmental pollution and exhaustion of resources – depends on good science and good scientists, and that dependence will grow [35].

Statistics

Statistics helps formulate ideas and questions precisely, determines how to gather and validate relevant information to address the questions, provides and enables scientific analysis of the data, and identifies the remaining uncertainty.

Statistics is a key tool for science and for rational public policy.

Public policy-makers need trustworthy information to help them take rational decisions, often in the face of uncertainty and risk [26].

Basic understanding of statistical science is essential to informed participation in public debate on societal issues of health, safety and risk.

Science and statistics are widely misunderstood, one as the repository of truth rather than the seeking of truth in an uncertain world, the other as the mathematical manipulation of masses of data rather than the interpretation of quantitative evidence. Scientists and statisticians are not generally involved in public-policy decisions in a systematic and productive way. It is appropriate to reconsider the role of scientists and statisticians.

SCIENCE AND GOVERNMENT

The Contrasting Cultures of Science and Government

The relationship between science and politics is necessary, sometimes close and often strained.

Science is generally about conclusions, whereas politics is about decisions. Politics requires the melding of many voices and interests; science is the search for unitary truth, to be pursued by means developed within the individual scientific disciplines.

The effective politician is a generalist and covers a wide field of human interests; the scientist is usually a specialist with a deep knowledge about some matters, but often little about unrelated areas.

The politician is generally an integrationist; the scientist tends to be a reductionist [9].

While science may suggest that one path is better than any alternative, that path may not be the one the politician feels obliged to follow for reasons the scientist does not consider.

These differences leave the scientist and politician with different world-views and different expectations about the nature and goals of collaboration.

In the short term, these differences can be ameliorated by attention to the organization and presentation of scientific advice to government. In the longer term trust and mutual *understanding must be actively developed between science, government and the general public. A broad,* liberal *education is key.*

Scientists, educators and governments each have a responsibility and a role to play in this development.

Providing Effective Advice

To be effective, scientific advice must be intelligible to the user, relevant and useful. It should be concise, accurate and open about uncertainties and difficulties. Sources must be accessible and referenced.

Properly provided, scientific advice helps inform the public and its governing bodies about the norms and processes of science, its strengths and limitations.

Advice must be timely, yet good advice often takes time and resources. A request for advice should be explicit in terms of available time and resources. These should be reviewed before a final plan is approved.

Science is public, and a strong science base is critical to the strength and welfare of a nation. Unless national security would demonstrably be compromised, proposals should be publicly available, with ample opportunity given for the public to comment. Direct dialogue with the public should move from being an optional add-on to policy-making to becoming an integral part of the process.

When there is wide scientific consensus on an issue (e.g., on the well-established harmful effects of tobacco), decision-making is not improved, and may be damaged, by giving equal time to minority adversarial or self-interested viewpoints (e.g., contrary statements by the tobacco industry which have no credibility and can only delay and confound steps to mitigate the damage).

When there is not wide scientific consensus, there must be opportunity for discussion and debate. Presentation of a range of options and rebuttals can be helpful, particularly at the highest levels of government.

Improving Government Access to Scientists

Policy-making can be greatly strengthened by including in the process those with experience in the relevant specialities [22]. Specialists who understand the roots of their profession know the values that need to endure in the face of changing technology or of political pressure. They see fads and poor science for what they are.

Some governments recognize this need [30]. To assist the process, independent professional organizations, including universities, need to develop better mechanisms to access government and for government to access their expertise.

In such collaboration, conflicts of interest (real or perceived) may be a serious problem which can threaten to undermine the credibility of research in the public's eye. Tough standards must be developed and implemented to prevent this.

Scientific Advice to Government

Policy-makers do not always ask the right questions in the right way, and statistics are often used inappropriately in either framing questions or in studying the effect of interventions [34].

Many problems require expert advice in areas that arise only infrequently, and knowledge about them may be completely lacking at the decision-making level. It is difficult for experts to build the depth of common experience or the mutual trust that is essential for effective communication.

The acceptance of scientific advice varies even when science and technology are dominant features of the matter (e.g., global climate change). This is understandable when scientific consensus is not available. An apparent lack of consensus can be artificially introduced by exploiting any lack of unanimity on some particular point [13].

Government departments sometimes equate secrecy with power. In the long run this is self-defeating. Secrecy works against the co-operation and involvement of academia and the professions.

The referral of some matter for scientific advice is sometime used as a ploy to delay or avoid hard decisions.

The scientist who serves in advisory role for government may have to do so at great cost to career plans.

A comprehensive strategy, including attention to policy-making structures, is required to promote good practice for scientific advisors and to protect them from exploitation.

Creating a Permanent Structure for Scientific Advice to Government

An institutional structure needs to be established at the national level (one model is the former Office of Technology Assessment in the United States) which can build the necessary trust among governments, scientists and the public, and mobilize the expertise that can make scientific advice effective.

Redundancy should be minimized, although some might be retained only to avoid a single point of failure. Each government agency, and indeed level of government, should consider how any proposed institutional structure would obtain independent scientific advice on a broad range of matters within the agency's mandate.

International organizations can be used by a group of countries with a common problem, by countries without the necessary resources for their own institutional structure, and by countries where it might be perceived that national interests unduly influence the scientific advice given by the separate national institutions (e.g., boundary resource disputes). Indeed, many crises that require scientific input are global in scale, and require an international response.

Good advice will sometimes be unwelcome. The mechanism should be made permanent and difficult to change, just as the permanence and independence of a statistical office (health, labour, economics, etc.) should be protected from political pressures.

Involving the Public

Governments are beginning to realize that they need to involve the public in developing policy in areas such as genetic engineering and xenotransplantation [27].

There is little understanding of how this involvement of the public should be done.

Scientists can and should play an important part in designing and implementing fresh models for public involvement [21, 29].

SCIENCE AND THE PUBLIC TRUST

Basis for Trust

Public trust in science has been built largely on the success of science in improving the lives of billions of people and the independence and self-disinterest traditionally accorded to scientists and to scientific enquiry. Nevertheless, scientists can no longer take public support for granted and need to address the question of maintaining public trust.

Public trust is built on personal experience. The public credibility of the medical profession, for example, begins at the individual patient and the degree to which the patient believes the physician is acting in his/her best interests. It also depends on the degree of confidence the public has in the medical profession's being able to police itself.

The medical model raises important questions for science and scientists. How much do scientists care for the welfare of the individual in society? Do they often think about their responsibilities to society? Should they expect support from society if they do not provide evidence of such concern? Are scientists concerned only with their careers, or their personal research, or their patents?

Coping with Controversy

Scientific controversy in inevitable, because science explore the unknown, and scientific understanding changes as knowledge develops [11].

Public controversy can erode trust. It is important, though difficult, to present scientific disagreements in a clear, impartial way in order that the public will be better informed, rather than further confused or even disillusioned by science in general.

Public interest intensifies when the outcomes of the science are potentially personal. Medical researchers find themselves at the sharp end of questions of public trust, as illustrated by the recent controversies regarding the risks of Creutzfeldt-Jakob Disease and bovine spongiform encephalopathy, predictions from extrapolation from animal models of toxicology to humans, and disagreements among experts on the risks of cancer due to exposure to environmental asbestos [8, 32, 33].

The major issues before the public are increasing in number and complexity. Public understanding requires that scientific information be readily available and clearly explained in non-specialist language.

Would different models for the interaction of scientists with society, for example that of the medical profession, be more effective in producing scientific credibility and in ensuring the proper public trust? [28]

Science and the Public Understanding: Bridging the Gap

There is a crucial gap between the public understanding of science and what scientists actually do, how they do it and why they reach the conclusions they do [10].

Science and its public perception should not be different. If they are, public trust in science and scientists can be eroded. The scale of the problem can be seen in recent public crises where a populist, as opposed to a scientific, appreciation of the risk has had great influence on governments' handling of such situations [32].

The place to begin is with scientific education at all levels – not just feeding students bits of interesting findings, but teaching them to understand the processes of science, how it really works and what makes it a unified whole in its search for truth.

Conversely, scientists need to learn about the various processes of public-policy formulation, legislation and the media [3, 12]. Academic graduate programmes have generally failed in this regard, from the types of student they admit, to the education and training they provide and finally to the career goals they inculcate.

SCIENCE AND EDUCATION

The Curriculum

Breaking down the barriers. Many ethical issues currently facing society are consequent upon recent advances in science, such a gene manipulation and biological and nuclear weapons. Others arise from cultural diversity and economic globalization.

Policies to deal with these challenges cannot be produced by experts on the basis of specialized knowledge alone. Future leaders of society, who will face these issues and who will often be university graduates, must be broadly informed and able to weigh evidence.

University curricula should enhance interaction among the humanities, social and natural sciences. This is now beginning to happen in some professional schools such as medicine [15].

Distinguishing fact and value. A major problem in both the public understanding of science and the perceived lack of trust in science is a general vagueness about the ability to determine causality in complex situations [5] coupled with the belief that it must be possible to calculate the probabilities of risks in complex situations with a minimum of disputable assumptions [24].

One aim would be to give each student sufficient understanding of the philosophical problems raised by science and the scientific method for him or her to be skeptical of claims of casualty reported in the press or elsewhere. Another would be to teach students that there are limits to measurement imposed both by language and the nature of the phenomenon under observation [24]. Disciplines should not pretend to be more quantitative, or more certain, than they really are.

All students should learn to recognize where fact ends and value judgements begin.

Funding Higher Education

Society's spending on education in terms of gross domestic product has not increased proportionately with the greater demand for tertiary education.

Governments are transferring more of the cost to students by having them pay (higher) tuition fees, forcing students to live on bank loans, and perhaps in the future, by introducing additional taxation for graduates.

Rising costs, together with industry's demand for highly qualified manpower, have led to governments restricting and directing funding along with a tendency to centralize and control funding [6, 21].

The funding of university education needs urgent resolution.

The Monitoring of Educational Standards

The state is becoming more intrusive, partly because of the increasing cost and perceived economic national importance of education and partly because of a concern for national and international educational standards in what have been historically independent institutions.

The model chosen for accountability has often been that of industry, based on quality assurance and experts judging the output of the educational process. The industrial model has indeed been immensely productive for industry, but education and public policy are different from industry and the industrial models may not apply.

Accountability of educational institutions requires competent and efficient methods of assessment [18, 19]. "Expert" assessment of university departments in the United Kingdom, for example, has been expensive and cumbersome and has led to misguided decisions and inappropriate attitudes at many levels [14].

Educational aims must first be clearly defined [2, 7]. They must be relevant [1], agreed upon and precise enough for clear evaluation.

The workload and stress of an evaluation must be proportionate to what is gained by that evaluation [7].

Promoting Statistical Understanding

Statistical reasoning applies wherever there is uncertainty, and there is uncertainty nearly everywhere. Statistics is essential to any depth of understanding of both science and government, but is poorly taught to both generalists and specialists. In both cases there is too great an emphasis on mathematical manipulations rather than on the interpretation of imperfect data [4, 25].

It is the processes of statistics, the value of evidence in testing an hypothesis, that should be taught. The most helpful exemplar for generalists may not always be the physics experiment but rather the medical clinical trial which has close connections with ethics and statistics.

Learning how to combine information from a variety of sources would help future policy-makers in all fields [31, 36].

Statistical education is not producing the kinds of graduate skills that are necessary for policy-making [4].

THE FUTURE OF THE CORE SCIENTIFIC DISCIPLINES AND LONGER-TERM RESEARCH

Dangers and Issues

Governments want entrepreneurial universities, and some universities have become major wealth creators as they develop skills in partnership with industry, promoting technology transfer and protecting their intellectual property rights. Economic spin-off from research is expected, even demanded [16]. Universities must indeed take their responsibilities to the economy seriously. But an over-emphasis on entrepreneurship can cause serious problems for fundamental research and teaching.

There is the ever-present danger of the politicization of research. Stem-cell cloning, global climate change and genetic modification of food plants and animals are obvious examples where political interests might influence (some would say, have influenced) the course of research.

There are also major issues relating to confidentiality, for example where a research consortium is comprised of one or more industrial partners allied with university researchers. Public funding of universities implies that results should automatically be in the public domain while commercial considerations may often suggest otherwise.

SCIENCE PRIORITIES RELFECT THE VALUES OF SOCIETY

We each value economic well-being, health, security, opportunity and fundamental freedoms, for ourselves and for others. Beyond these, we treasure discovery, the cultivation of knowledge, science and artistic expression, each in and of itself as providing the means to better understand ourselves and our world. Such values distinguish human society. Public policy-makers and scientists should work together to nurture and promote these enduring values, based foremost on reason, conscience and the best information available.

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