LETTERS

Social Research Support

Science is entitled to print an opinion of the National Science Board's statement on the social and behavioral sciences, but the response we have received from the community most involved differs from the "tepid" assessment by Constance Holden in the 31 July issue (News and Comment, p. 525). I think it is unfair to interpret the Board's statement for *Science* readers without affording them the opportunity to apply their own intellectual thermometers to the original text, which follows.

The National Science Foundation (NSF) is by statute responsible for the health of the scientific enterprise of the United States. The social and behavioral sciences are an integral part of that enterprise. During the spring of 1981 the National Science Board gave special consideration to social and behavioral science research activities. It reviewed the history of NSF support in these fields, major contributions of social and behavioral science research through the years, the current status of scientific research issues, the availability of other funding sources, and the current operations of the two National Science Foundation divisions. In addition it has received reports from and interviewed distinguished scientists in these fields.

As in all sciences, NSF's unique role is the enhancement of scientific capability and the development of the tools of inquiry. The Foundation provides the major support for all social and behavioral sciences where the focus is enhancing the objectivity of the sciences and improving the quality of data collection and analysis. Such support in the last decade has led to significant progress in the development and refinement of tools, techniques, and analytic capabilities. As a consequence of these methodological advances, new linkages have been forged among the disciplines and between these sciences and the biological sciences. As an example, substantial progress in cognitive research has been made through the joint efforts of psychologists and other behavioral scientists working together with biologists. This progress, combined with the extraordinary achievements in the neurosciences, gives promise for the future of major new understandings.

Our society is increasingly technologically based, and, increasingly, these technologies draw upon the skills and talents of social and behavioral scientists. In this context, there is a pressing need for the development of rigorous procedures for detecting and measuring both intended impacts and unintended effects. The research results of the social and behavioral sciences address these needs.

The fundamental research supported by NSF underpins and strengthens the mission oriented research programs of other Federal agencies and improves the quality and usage of national statistical information. It also contributes to important private sector activities utilizing economic forecasting, demographic projections, survey research, cost benefit analysis, marketing analysis, and personnel selection and training.

The National Science Board believes that support for the social and behavioral sciences, as with all sciences, should continue to be based on criteria of research quality as judged by rigorous critical standards. The Board believes it is imperative to have resources adequate to mount a balanced program. Such a program must include maintenance of large data bases, improvement and strengthening of research methodologies, and provision of opportunity for innovative investigator initiated projects. The long-range interests of the country require a continuing base of adequate support of the social and behavioral sciences so that the research base and intellectual vitality the United States has established in these fields can be maintained and increased.

Let me assure *Science* readers that the National Science Board intended its statement to be both positive and clear. The Board's statement resulted from a recent review of the National Science Foundation's role in the support of the social and behavioral sciences culminating at its meeting in June 1981 when the statement was adopted.

The National Science Foundation does not include "casual kinds of research" in its programs in any field of science or engineering. This quote, attributed to me as a characterization of social science, was taken out of context from a telephone interview on a different occasion with another reporter.

The Foundation's support of social and behavioral science research is part of its support of fundamental scientific research, and relevance for policy-making is not the primary test for research in any field of science. Our primary emphasis is on the vigor, integrity, and validity of the methods, ideas, and data in the field. In fact, research to improve the rigor of survey methodology has been one of the Foundation's special emphases so that confidence in the results of this widely used tool is enhanced.

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Oil Exploration

Statistical extrapolations are always chancy, but especially if the mechanisms for past events are not appreciated. Hall and Cleveland (6 Feb., p. 576) use drilling data and oil discoveries since 1945 and conclude that oil drilling in the United States could cease to be a net source of energy by the year 2000.

The most important parameter for explaining the past and predicting the future is not brought out by Hall and Cleveland, and that is the price of oil. If prices continue to rise in the future as they did in the last decade (by a factor of 20), then drilling will continue to be profitable. On the other hand, if prices stabilize or decline (in real terms), then drilling may become uneconomic even sooner than 2000 in many locations. It is unhelpful in any case to use net energy arguments; drillers use net dollars as a decision parameter.

Oil prices must also be used to explain the past variations of drilling effort and of finding rates per foot drilled. Drilling effort would be expected to correlate with oil prices, and therefore with profits from drilling. Indeed, the decline in effort from 1955 to 1970 coincides with falling oil prices (in constant dollars). The inverse correlation between drilling effort and finding rate bears no analogy to the corresponding relation in fisheries (that is, between fishing effort and catch) suggested by the authors. Instead, during periods of high oil prices, drillers not only drill more, but are also inclined to tackle less promising prospects which yield less oil. Similarly, changes in the tax laws, or some other actions by the government, can either encourage or discourage unproductive drilling (*1*) and thereby affect the finding rate per foot drilled.

Hall and Cleveland question whether the present trend of increased oil exploration is in the national interest. Unencumbered by a "net energy" analysis, I conclude that, as long as individual drillers find exploration economic, and provided there is no general subsidy or tax to distort their decisions, the nation as a whole benefits.

But this is a partial analysis. If we could tax away the profits of OPEC and there were no security considerations attached to oil imports, then general results from welfare economics dictate that the lowest cost resource, that is, Arabian oil, should be used first, before higher cost resources are developed elsewhere.

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References

1. S. F. Singer, *Science* **188**, 401 (1975); *Eos* **56**, 886 (1975).

We welcome the opportunity to make the point again that net energy analysis is not antithetical to economic analyses but is instead closely linked. Singer is correct in stating that drillers use net dollars as a decision parameter and that drilling effort (but not success) has been more or less correlated with the real price of oil and gas. But what is cause for Singer is effect for us. Certainly, the physical sup-

ply of domestic petroleum has a great deal to do with its price and also the price others can charge us for their petroleum. We would expect that the time at which energy costs approach energy gains will in large part determine the time at which drilling for petroleum as fuel ceases to be economically profitable. A possible exception, stated explicitly in our report, is that some drillers will undoubtedly make a profit by using coal to find and pump oil for petrochemical feedstocks—or even for gasoline for those wealthy enough to afford it—even after the energy return on energy invested is negative. Unfortunately, since more than half of our nation's present energy requirements are met by domestically produced petroleum (found and produced with petroleum as the principal energy source), the driller's profits would be of little recompense for the rest of us who require these fluid hydrocarbons to sustain our present level of economic activity and material well-being.

We believe that the mechanisms Singer finds wanting are stated explicitly in our report and that our analysis negates the importance of Singer's (*1*) earlier observation—that oil was found at an approximately constant 35 barrels per (exploratory) foot from 1950 to the early 1970's—because in general effort was decreasing then.

One problem with Singer's apparent faith in the market is that the market may fail to give needed signals about the future, that is, if estimating future national energy supplies is at least as important as estimating future profits for drillers. In principle, economic analyses could be used to make predictions, but such analyses are improved by including physical information about the resource such as that provided by our and similar analyses (*2*, *3*). A second problem associated with leaving all decisions to the marketplace is one of discount rates. The recent factor of 20 increase in the value of oil left in the ground was much greater than that of money drawing interest, an occurrence that was apparently unforeseen in financial circles in 1972 but one that perhaps could have been predicted from Hubbert (*2*). And, if the amount of oil left to be found is as limited as our and other (*2*, *3*), analyses suggest, then the search for oil now depletes our nation's remaining reserves more rapidly and decreases the incentives to make the hard decisions as to what we should do next. The present Administration's policy of largely discounting the future (for many resources) in order to increase present-day economic activity is consistent with some free-market principles but may do little to ensure adequate future resources.

We agree with Singer that government subsidies and taxes can distort, often undesirably, free-market resource decisions; there is at least one case (*4*) where net energy analysis has identified some oil fields that were pumped at a monetary gain but an energy loss due to federal price regulations. We also agree with Singer's last paragraph and add that by importing oil we can leave our own somewhat meager resources in the ground, thus giving us more flexibility to meet future contingencies.

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References and Notes

1. S. F. Singer, *Science* **188**, 401 (1975); *Eos* **56**, 886 (1975).
2. M. K. Hubbert, *Bull. Am. Assoc. Pet. Geol.* **51**, 2202 (1967); *Senate Comm. Interior Insular Affairs Ser. No. 93-40* (92-75) (1974).
3. H. W. Menard and G. Sharman, *Science* **190**, 337 (1975); H. W. Menard, *Sci. Am.* **244**, 55 (January 1981); E. F. Osborn, *Science* **213**, 156 (1981); R. Nehring, "Giant oil fields and world oil resources" (Publ. R-2284-CIA, Rand Corporation, Santa Monica, Calif., 1978).
4. M. Gilliland, in *Energy Analysis, A New Public Policy Tool* (Westview, Boulder, Colo., 1978), p. 10.

"Affordable Science": Another Perspective

While I do not wish to detract from the issues raised by William D. Carey (Editorial, 1 May, p. 497) with regard to federal budget cuts affecting science funding (and in particular funding for the social sciences), these cuts may turn out to be a mixed blessing.

First, it has been pointed out that science is not unaffected by interests which to some not insignificant extent condition both the questions asked and the results produced (*1*). It may be the case that the disengagement from areas of research by the government will remove certain governmental prejudices and vested interests as to what "questions need and are worth studying." This disengagement could produce a more desirable effect that scientific research may become more open and free to respond to the curiosity and interests of the investigator.

Second, it appears to be the case that contemporary science is fraught with the consumer mentality of our day, namely, that "the more expensive it is, the better it must be." Perhaps by reducing funds the government will (inadvertently, no doubt) challenge scientists to do "affordable science" and still produce the excellent research of ages past when it was somehow unnecessary to have huge grants and expensive equipment to support inquiry into natural phenomena. It may be that these budget cuts may serve to make science more accessible and less formidable an enterprise because more people would see legitimate science within their own economic means to engage in it. I remember Eckhart Hess' story about his research on space perception in chicks. He conducted this significant piece of investigation with an expenditure of less than $3. To me, that is "affordable science."

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References

1. J. Habermas, *Knowledge and Human Interests* (Beacon, Boston, 1971); M. Polanyi, *Personal Knowledge* (Univ. of Chicago Press, Chicago, 1962); R. R. Wilson, *Bull. At. Sci.* **37**, 1 (April 1981).

Growth in Publishing

In 1976, *Nature* published my letter (*1*) calling attention to the JPU, or "Just Publishable Unit," which I defined as the smallest amount of information that is normally accepted for publication as a separate item in a scientific journal. Perceptive remarks about the JPU were subsequently made by Waugh (*2*) and Kerr (*3*).

Recently, *Science* printed an article introducing essentially the same concept, named the LPU or "Least Publishable Unit" (News and Comment, 13 March, p. 1137). The article discusses the need to avoid publishing material that duplicates other observations and quotes scientists who bemoan the explosive growth in scientific publishing. I estimate that the *Science* article was 27 times longer than my letter.

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References

1. D. Fraser, *Nature (London)* **260**, 92 (1976).
2. C. G. Waugh, *ibid.*, p. 572.
3. S. R. Kerr, *J. Fish. Res. Board Can.* **34**, 580 (1977).

Erratum: In the article "A firing over formaldehyde" (News and Comment, 7 Aug., p. 630), the directors of two agencies were incorrectly identified. The head of the biology division at Oak Ridge National Laboratory is Richard Griesemer. The head of the National Institute of Environmental Health Sciences is David Rall.