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The Nationalization of Basic Science

Overzealous Attempts to "Protect" Scientific Integrity will Damage American Science as a Whole

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The Perceived Problem in Science. The National Institutes of Health (NIH) instituted draconian new ethics rules, this past February, aimed at protecting its reputation, which had been damaged by a series of revelations about conflicts of interest among its researchers.[i] The new rules forbid NIH employees—both research and support staff—and their spouses and dependents from holding significant financial interests in or receiving fees from drug, biotechnology, and other medically-oriented companies.

The announcement of the rules was met with derision[ii] from NIH staff, and has led to some high-profile resignations, including those of the head of the National Institute on Deafness and the newly-appointed head of National Institute of Environmental Health.[iii] The chairman of NIH's department of clinical bioethics, Ezekiel Emanuel, asked, "If we really want to reassure the public, why don't we apply these to everyone who gets an NIH grant?"

That may well be the next step. A recent study published in the journal *Nature*[iv] that asked over 3,000 recipients of NIH funding about scientific misconduct found that 15 percent admitted to "[c]hanging the design, methodology or results of a study in response to pressure from a funding source"—though only 0.3 percent admitted to actual falsification or "cooking" of research data. Still, the study empowered lobby groups like

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the Alliance for Human Research Protection to argue,[v] "The fact is, Big Pharma could not possibly have succeeded in undermining the integrity of American medicine without the complicity of leading academics at premier medical institutions—including Harvard, Yale, Columbia, Johns Hopkins, the University of California, and the National Institutes of Health."

Yet this attitude—that private sector interests are corrupting science and that anyone who has any association with a private sector interest is somehow tainted—presents a greater danger to American science than the alleged problem of conflict of interest, which is, in reality, a paper tiger.

In fact, the real problem facing science is not corporate influence, but too much government influence. When former *New England Journal of Medicine* editor Marcia Angell argues that pharmaceutical science and industry should "be regarded much as a public utility[vi]," it becomes clear that the real danger for science is not the influence of private industry, but *de facto* nationalization.

To understand exactly why, we need to examine the way in which science is structured in the United States today, the justifications advanced for that arrangement, and the economic realities that refute it.

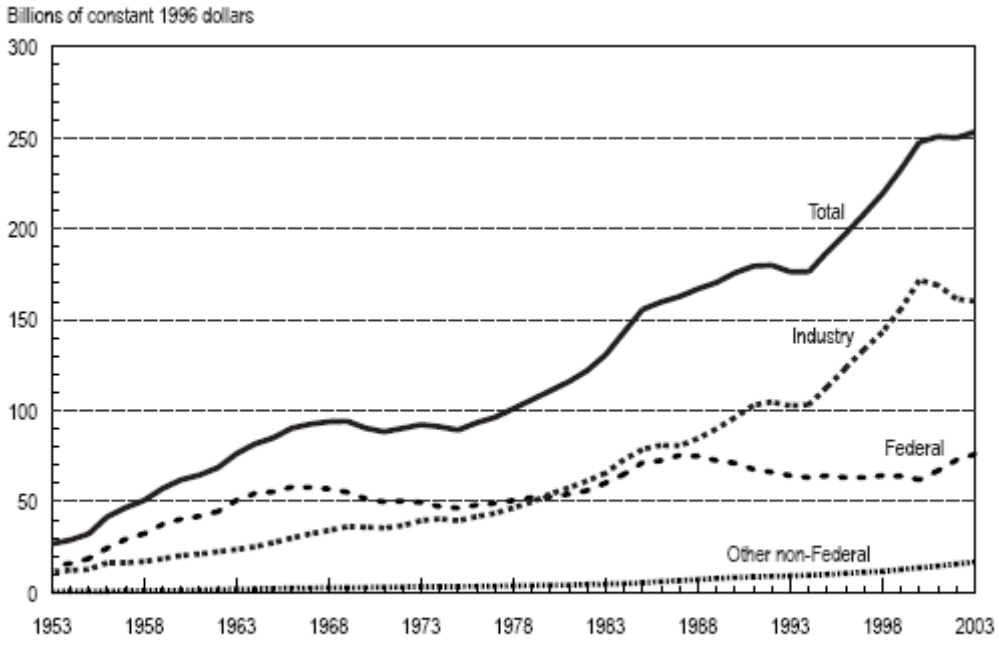
Basic and Applied Science. The current paradigm of scientific research and the justification for government involvement was developed by President Franklin D. Roosevelt's top science adviser, Vannevar Bush, and gained its dominance in the military research-driven circumstances of the Second World War and the Korean War.[vii] It relies on what is known as the "Linear Model" of science, which states that "basic research"[viii] develops a pool of knowledge from which "applied research"[ix] draws practical benefits, which are then developed into economic goods. The entire process is called "Research and Development," or R&D. In diagrammatic form, the model can be depicted as:

Academic Science → Technology → Wealth

The model recognizes that industry is likely to fund applied research and development, but maintains that basic research, being academic in character and generally producing results that are not immediately translatable into profit, is unlikely to be funded by the private sector. Therefore government funding is justified on the grounds that it will be returned in economic wealth at the end of the R&D process.

This model was applied to the extent that the federal government was the major supplier of R&D dollars in the economy from Vannevar Bush's time until 1980 (see Figure 1).

Figure 1. Total R&D Investment by source of funds, 1953-2003



SOURCE: National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources*, annual series. See appendix tables B-2 and B-22.

Since 1980, however, the situation has changed markedly. Industry is now the major funder of R&D in all areas except basic science, where government provides just over 50 percent of funding:

Figure 2: Investment in Basic Research (figures in millions of dollars).

Sources of Funding by Sector, 2000: Basic Research

	Funding Source			
	Federal Govt (1)	Industry	Universities/ Non-Profits	Totals
Federal Government	3,525			3,525
Industry	1,883	14,199		16,082
Universities and Colleges	17,017	1,421	5,027	23,465
Other Non-Profit Institutions	2,237	602	1,991	4,830
Totals	24,662	16,222	7,018	47,902
	51.48%	33.86%	14.65%	

(1) Includes other non-federal governmental funding to universities and funding via federally funded research & development centers

Source: Statistical Abstract of the United States 2002, US Census Bureau, Table 754: Performance Sector of R&D Expenditures 1995 to 2000

Therefore, government is not a particularly dominant force in basic research, since the private sector—defined as industry plus private academic sources of funds such as

universities and foundations—funds just under 49 percent of all basic research in the nation, which in turn represents only 18 percent of total R&D spending.[x] Thus, government investment in basic research accounts for just over 9 percent of the economy's investment in R&D. This raises significant questions about the Linear Model, the importance of government spending, and the role of basic research in the economy as a whole.

The Artificial Nature of the Linear Model. The Linear Model has been recognized by students of science policy as inadequate for some time. As Roger Pielke Jr. and Radford Byerly Jr. of the University of Colorado point out,[xi] the model rests on a terminological sleight of hand by Vannevar Bush. Before his redefinition of it as "basic research," the concept to which Bush referred was known as "pure science," an endeavor supposedly far nobler than mere applied science. Yet eminent scientists such as T.H. Huxley and Louis Pasteur resisted the distinction, regarding it as false. To them, the value of science lay in its utility, not some intrinsic "nobility."

Physicist Burton Richter captured the falseness of the distinction in an essay in the journal *Physics Today* in 1995, when he wrote, "The road from scientific discovery to new technology is a wayward one.[xii]" Yet it is the pioneering work of British biochemist Terence Kealey that best demonstrates the model's inadequacy.[xiii]

Kealey demonstrates from a variety of sources that the flow of science is not one way. Much of new technology derives from advances in old technology rather than from basic research[xiv]; academic research can be inspired by technological development, as was the case with the development of radioastronomy and even the Big Bang theory[xv]; and there is often cross-fertilization between the two, as is the case with solid state physics[xvi].

Kealey therefore proposes a refinement of the linear model to:

Basic science ↔ Technology → Wealth
↑ ↑
Old science Old technology

Science's role in the economy, it appears, is mainly dependent on the technological portion—the applied research and development—of the model. Basic research contributes far less than the linear model suggests. Thus, approaching science policy by looking at basic or academic science as a starting point and extrapolating from it is misguided. Science policy should focus instead on the development of technology.[xvii]

The Danger of "Pure Science" Nevertheless, there is no doubt that basic research does contribute value to our economic well-being. That is why the current obsession with conflicts of interest is so potentially damaging. It threatens to sever the link between basic science and technological development altogether.

The reasons are several. First, industry is now the dominant player in the scientific game, contributing almost 70 percent of all scientific funding. That means that most of our

current science is carried out by, or on behalf of, industry. Attempting to cleanse academic science of contacts with industry would create a scientific ghetto of "pure scientists," who would sever not only financial but also most academic links with the dominant player in the scientific game, because interaction with industry-funded science will become much more difficult.

The corollary of this ghetto-formation, of course, is that, like all ghettos, movement will be one-way – out. Bright scientists will leave the ghetto for the bright lights of industry, where both remuneration and opportunities will be better. The scientists who remain in the ghetto, on the other hand, will see their prospects dim. Something similar has already happened in the United Kingdom. The British government has funded large numbers of university science posts, but, as the dominant funder, has kept academic scientists' salaries low. As Kealey notes:

> A Cambridge University professor during the 1930s, when there was still an academic free market, earned around £80-90,000 a year at current prices (perhaps double that of medical general practitioners) but today he only earns about £37,000, significantly less than a medical general practitioner.[xviii]

Second, there is a significant chance that instituting a "pure scientist" approach to academic science will harm the economy. Not only will the cross-fertilization of ideas with applied science and technological development dry up, but thinking of academic science as somehow "nobler" than the other functions carries its own economic dangers. Again, the UK provides an example in the attitude and deeds (or misdeeds) of the Medical Research Council (MRC) there.

In the 1940s, one of the discoverers of penicillin, Ernst Chain, tried to persuade the MRC to patent the new wonder drug. The Secretary of the MRC responded that only tradesmen tried to make money from science. As a result, American drug companies patented the drug while British taxpayers paid millions in royalties to use the drug whose discovery they had funded. Exactly the same thing happened with monoclonal antibodies in the 1970s, with the result that British taxpayers lost out on £200 million of royalty income every year. Such are the economic perils of ignoring financial interests in science.

Another problem likely to arise if academic science severs its links with industry is that the Linear Model itself will suggest that government's funding of academic science will become much less justifiable. If the synergy between academic science and applied science suffers, then the economic benefit supposedly derived from funding academic science also suffers. Why then, should government continue to fund much of academic science? This already small sector (as we have seen, only 9 percent of the R&D effort in the United States) will decline even further.

Moreover, private funding sources will almost certainly move to fund basic science themselves—not that this would be a bad thing. They will, as mentioned above, secure the exclusive services of the brightest scientists through attractive job packages that the

"pure science" employers cannot hope to match. As the NIH controversy has shown, industry currently secures the advice of the best academic sciences through consultancy arrangements. If those are outlawed, then they will secure their advice by direct employment—and those scientists hired by industry would then become isolated from their academic colleagues.

The likely direction that an academic scientific establishment shorn of all ties to industry would take would therefore be self-destructive. Yet it is also worth examining the philosophical justification for banning such ties.

What Exactly is Wrong with Conflicts of Interest? A leading proponent of the idea that working for industry forever taints a researcher is Dr. Jerome Kassirer, who, like Marcia Angell, is also a former editor of the *New England Journal of Medicine*. Dr. Kassirer, author of *On the Take: How Medicine's Complicity with Big Business Can Endanger Your Health*, wrote in *The Washington Post* last year that NIH's cholesterol guidelines were tainted precisely because in the past some of the authors had received grants, fees, or both from drug manufacturers. Disclosure of interests, he argued, does not work because it tells us nothing about whether the potential bias tainted the advice. The only way to ensure it does not is to ban those with any conceivable conflicts of interest from giving advice.

This is absurd, not just in its outrageous implied slur on the scientists' characters, but also because it inexcusably ignores the very real biases from other sources. Dr. Kassirer and his partisan allies appear to have never heard of the branch of economics known as public choice theory, whose principal thinker, James Buchanan, won a Nobel Prize in 1986. Essentially, public choice points out that politicians, regulators, and official bodies (like the NIH panels) are no less self-interested than private industry. Therefore, those who receive their salaries ultimately from government are likely to argue in favor of more government.

Thus, a panel of supposedly disinterested academics might argue in favor of tighter regulation of pharmaceuticals in the knowledge that they will benefit from their government advisory roles. Contrary to Dr. Kassirer's apparent belief, there is no class of researchers immune to conflicts of interest. Suffice it to consider his own potential conflict of interest. As regards his book, he stands to benefit from people worrying about this alleged "complicity," since it might boost sales of his book. By his logic, we should dismiss his alarmist claims as nothing more than a sales ploy. He is asking us not to trust him.

And financial gain is not the only motivation. Even if Dr. Kassirer were to give away his entire book sale profits, causes that he supports will benefit. For instance, Daniel Klein of Santa Clara University recently found that 75 percent of authors and all editors of the *Journal of Development Economics* have ties to international development institutions. That they might argue for more government funding for the organizations they support should not be surprising.

Conflicts of interest are a fact of life. Rather than try to eliminate them, the way to address them is to make people aware of them. Consider the ongoing acrimonious debate over media bias in America—centered on the shocking revelation that journalists have views of their own. In Britain, newspapers short-circuited that debate long ago by openly declaring their editorial policies. Without a pretense of objectivity, the public know what they're really getting. Contra Dr. Kassirer, disclosure works.

If we accept that everyone acts out of self-interest, then we can also accept, as did Adam Smith in 1776, that society benefits from people acting out of enlightened self-interest. He said, "It is not from the benevolence of the butcher, the brewer, or the baker, that we expect our dinner, but from their regard to their own interest." This works just as much in science as it does in baking.

While government-funded research can push scientific advancement along, the marketplace has proven much better at pulling it along. Repeated academic studies, cited by Kealey,[xix] show that the consumer profits twice as much from an invention as the inventor.

Long before Adam Smith, the Roman statesman Cicero formulated the question "Cui bono" (who benefits?) to get to the root of who committed a crime. If the answer is "the American people," as has been so often the case when industry has helped advance scientific knowledge, then it should be clear that no offense has been committed.

Science's Self-Correcting Mechanisms. Even when misconduct does occur—and this paper accepts that it clearly does—science has developed its own detection and self-correction mechanisms. If the misconduct survey cited earlier tells us anything, it is not that those mechanisms are inadequate for their purpose, but that science itself has not used them properly.

Scientific inquiry progresses by means of research, publication, and replication. If research is somehow altered to produce results that are not warranted by the actual data, then that is falsification, perhaps the worst sin a scientist can commit. The publication process is designed to catch such examples by means of peer review. Reviewers should examine the methodology, data sources, and results of the submitted article. Falsification would be apparent if reviewers acted at the level of due diligence shown by, for example, the reviewers of a financial prospectus. Sadly, reviewers are not generally paid (never mind paid at the level of financial lawyers). This has led to several high-profile faulty articles making it through the peer review process to publication in recent years.[xx]

Even if peer review fails, the next step is replication. It is a central principle of science that others should be able to replicate a discovery. If they cannot, then the discovery is not accepted (as was the case with the "cold fusion" phenomenon.) This step is particularly important with scientific discoveries that have commercial or economic potential and is one of the main reasons why industry spends so much on research. Even if the discoverers of, say, a new drug have patented that drug, other pharmaceutical companies will want to see if they can invent a similar drug that does the same job better.

A good example is the case of the various stomach acid-reducing medications known as histamine-2 blockers. The very first such drug, Tagamet, was developed by the pharmaceutical firm SmithKline. When the developer, James Black, described his discovery at a lecture, a researcher for rival firm Glaxo, David Jack, determined to copy the research but produce a much more potent derivative.[xxi] He succeeded, and the newer drug, Zantac, quickly became the market leader. As Jack said, "It was a straight piece of medical chemistry because the original thinking had been done by Jim Black. It does, however, show something very important. The second prize in this business can be bigger than the first."

Ironically, the certainty that comes with replication seems to be much less important in academic science (as the controversy over paleoclimatological temperature reconstruction shows). This may be due to the pernicious influence of government funds. Because the justification for basic scientific funding under the Linear Model is to produce new research to be added to a pool from which applied science can be drawn, grants are normally given for original research, not for replication or checking of someone else's original work. A better funding mechanism might encourage more replication and thus ensure scientific self-correction.[xxii]

The importance of replication as a guard against failures of peer-review is shown by a new report in the *Journal of the American Medical Association*[xxiii]. It revealed that 16 percent of highly-cited medical studies were contradicted by subsequent ones, and another 16 percent were shown by later trials to have overstated results. In short, almost a third of medical studies – ones that were cited over 1,000 times in subsequent studies and articles – were found to be flawed. In medical science, the replication check is working. It is quite plausible that in other areas it is working less well.

At its best,, the scientific method as properly practiced encourages "double-loop" research, where the researcher will check his or her own results to avoid their being shown inadequate by the publication and replication processes. If the scientific community fails to enforce the checks of publication and replication then there is much greater opportunity for scientific misconduct. Science can and should police itself better if it wishes to reduce misconduct. This may, of course, require corrections to the process to reduce perverse incentives.

A Note on Science and Policy. There is another, related sphere, where science and politics intersect in the legislative arena, and where some allege that industry has a distorting effect on science. One such allegation is that moves to ensure scientific integrity in the regulatory sphere—such as the federal Information Quality Act or the moves by the Office for Management and Budget (OMB) to institute a peer review process for scientific studies used by agencies in developing regulation—constitute an attempt by industry to derail science-based regulation.

The charge represents a misreading of the dynamic at work. Industry, of course, has a right to engage in the political process to stop harmful regulation just as much as

industry's critics have a right to urge regulation if they think it is justified. But the opposition to the measures in question grows out of another misconceived interpretation of the Linear Model of science.

In this interpretation, science's value to society is expressed in the belief that it can cure societal problems:

Academic science → Answers to policy problems → Societal benefits

This is the model that causes many politicians to call for "science-driven" or "science-based" solutions. It institutes a paradigm of science discovering answers to policy problems.

Yet policy problems rarely find only one answer. Similarly, science rarely produces only one answer to a policy problem. When it seemingly does, it is often an indication that the science has already become unacceptably politicized so that other politically unacceptable answers are downplayed. On the other hand, relying on the Linear Model to produce clear answers to a policy problem when it is the reality that the science is so complex that this is unlikely to happen is an example of political problems becoming "scientized."[xxiv]

Recognizing that science cannot provide the answers, and that it is one of many inputs into the political process, requires that the political process protect itself against the Linear Model. In fact, the Supreme Court recognized the need to protect the judicial system itself from the equivalent argument in its sphere, when, it ruled in 1993 that checks and balances needed to be imposed on the increasing tide of often contradictory scientific evidence presented in aid of disputants.[xxv]

The Federal Information Quality Act is one example of the political process protecting itself against the idea that science demands certain actions must be taken. The Act establishes standards and procedures to improve the quality of agency-disseminated information. It also requires OMB and the agencies to establish "administrative mechanisms" whereby "affected persons" can petition agencies to correct erroneous information. The Act is clearly aimed at protecting the political process from over-hasty regulation based on the idea that information, rather than vested interests, drives regulation.

Indeed, OMB demonstrated that the claims against agencies made under the Act in its first year of operation came from all segments of society:

> OMB is pleased to report that the Information Quality Act has been used by virtually all segments of society. Correction requests have been filed by private citizens, corporations, farm groups, trade organizations, both liberal and conservative non-governmental organizations (for example, the Competitive Enterprise Institute (CEI), Wrestling Coaches Association, Sierra Club, John Muir Society, and Public Employees for Environmental Responsibility), and even other

government agencies (an Air Force correction request to the Fish and Wildlife Service). The Information Quality Act has even been used by four U.S Senators (a joint request by Senators Boxer, Jeffords, Lautenberg and Sarbanes to EPA).[xxvi]

The Act's use by such a wide array of complainants puts the lie to the charge that it constitutes a case of industry attacking science.[xxvii] Indeed, in the latest example of the use of that Act, its "founding father," Jim Tozzi of the Center for Regulatory Effectiveness, has teamed up with medical marijuana activist Steph Shearer to challenge the Administration's position that marijuana has no medical efficacy[xxviii], a position that seems to rely on the Linear Model.

Conclusion. The Vannevar Bush Linear Model of science has confused America's interaction with science for too long. The entire scientific process includes applied research and development that contributes greatly to America's well-being. Industry is a vital, indeed dominant, part of that process. Attempts to protect the "purity" of academic science by *de facto* nationalization would merely break off a segment of science and isolate it from the wider scientific process to its own detriment. Similarly, accusations of industry distorting science for political gain fail to recognize the proper role of science in the political process.

America needs to drop its attachment to the Linear Model and think of science more holistically. Science plays a much more complex role in the nation's life and politics than simplistic models admit.

Notes

[i] Rick Weiss, "44 Violated Ethics Rules, NIH Director Tells Panel," *Washington Post*, July 15, 2005
[ii] Rick Weiss, "NIH Workers Angered by New Ethics Rules," *Washington Post*, Feb. 3, 2005
[iii] "Tough ethics rules at NIH force more staff resignations," *Nature* 434, 814-815 (14 April 2005)
[iv] Martinson, B.C. et al, "Scientists Behaving Badly," Nature 435, 737-738 (9 June 2005)
[v] http://www.ahrp.org/infomail/05/06/11.php
[vi] Angell, M., "The Truth About the Drug Companies," New York Review of Books, Vol. 15, No. 12 (July 15, 2004)
[vii] "Science The Endless Frontier: A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development, July 1945," United States Government Printing Office, Washington: 1945
[viii] Defined by the National Science Foundation as follows: "The objective of basic research is to gain more comprehensive knowledge or understanding of the subject under study without specific applications in mind. In industry, basic research is defined as research that advances scientific knowledge but does not have specific immediate commercial objectives, although it may be performed in fields of present or potential commercial interest."
[ix] Defined by the National Science Foundation as follows: "The objective of applied research is to gain the knowledge or understanding to meet a specific, recognized need. In industry, applied research includes investigations to discover new scientific knowledge that has specific commercial objectives with respect to products, processes, or services."
[x] $47,903 million out of a total R&D expenditure by all sources of $264,622 million in 2000.
[xi] Pielke Jr., R.A., and Byerly Jr, R., "Beyond Basic and Applied," Physics Today, February 1998, 42-46.
[xii] Richter, B., "The Role of Science in Our Society," Physics Today, September 1995.
[xiii] Kealey, T., "The Economic Laws of Scientific Research," Macmillan Press, London: 1996.

[xiv] E.g, Mansfield, E., "Academic Research and Industrial Innovation," Research Policy, 20, 1-12 (1991), where the author finds that only about 10 percent of industrial advances are due to academic research.
[xv] Kealey writes (p. 217), "Two…Bell Lab employees, Penzias and Wilson, studying the problems of microwave transmission, discovered the cosmic microwave background radiation, and made the experimental observations that underpin the Big Bang theory (they won Nobel Prizes in 1978)."
[xvi] The invention of the transistor in 1948 by a Bell Labs employee led to universities teaching solid state physics, which has in turn led to semiconductor development.
[xvii] These thoughts, and what they mean for government involvement in science funding, will be developed further in a forthcoming Issue Analysis from CEI entitled, "Separating Science and State."
[xviii] Kealey, *op cit*.
[xix] E.g. Mansfield, *op cit*.
[xx] This includes examples such as the *Lancet* article that suggested that the MMR vaccine was linked to autism, which has since been withdrawn, and the incredibly complex issue of reconstruction of paleoclimatological temperature trends, where the data, although not fraudulent, appear to have been mishandled (see www.climateaudit.com).
[xxi] This is described in Kealey, p.226-7
[xxii] See CEI's forthcoming Issue Analysis, "Separating Science and State."
[xxiii] Ioannidis, J.P.A., "Contradicted and initially stronger effects in highly cited clinical journals," Journal of the American Medical Association, 294: 218-228 (July 15, 2005)
[xxiv] See, for example, Sarewitz, D., "How science makes environmental controversies worse." *Environmental Science & Policy,* 7, 385-403 (2004).
[xxv] Daubert v. Merrell Dow Pharmaceuticals (92-102), 509 U.S. 579 (1993).
[xxvi] Office of Management and Budget, "Information Quality; A report to Congress Fiscal Year 2003," OMB: Washington 2004.
[xxvii] The liberal advocacy group OMB Watch claims that 72 percent of complaints under the Act are submitted by industry. It derives this figure, however, by including in the figure of 133 complaints by industry 87 complaints against the Department of Transportation that are routine requests to correct individual data items on Federal Motor Carrier Safety Administration reports that are now handled by its Information Quality Act process. The requests were not stimulated by the Act.
[xxviii] Eric Bailey, "Activist Enlists Unlikely Ally in Bid to Legalize Pot," Los Angeles Times, July 18, 2005.