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ESSAY

THE UN-EASY CASE FOR TECHNOLOGICAL OPTIMISM†

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“Technological optimism” is a term of art, an article of faith, and a theory of politics. It is a view that pervades modern attitudes, yet gets little explicit attention. For a brief period the situation was otherwise. In the early 1970s, the optimistic outlook figured prominently in an important debate about nothing less than the future of the world. Technological optimism won.

The outcome was unsurprising, given the nature of the argument. On one side of the debate was a group of self-proclaimed Malthusians who foresaw an impending period of stark scarcity unless relatively drastic remedial steps were quickly taken; on the other side were the technological optimists, whose message, essentially, was not to worry — at least not too much. The two sides moved quickly to joinder on an issue that neither could carry. The debate, in other words, reached a dead-end; it came down to believing whatever one wished. Most people wish to be optimistic. This is why the optimists triumphed. It is also why, today, critical discussion of the optimistic viewpoint is largely passé. The literature on the subject is more or less closed. Not many people know very much about it, lawyers in particular. The exception might be those who work and teach in fields like environmental law and natural resources, where technological optimism has a special relevance and a notable dominance.¹

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1. The relevance of technological optimism to environmental quality and other natural resources will become plain as we go along. For evidence of the dominance of technological faith (and technological fixes) in environmental policy, past and present, see, e.g., J. KRIER & E. UR-SIN, *POLLUTION AND POLICY* 277-87 (1977); Ackerman & Stewart, *Reforming Environmental Law*, 37 STAN. L. REV. 1333 (1985); La Pierre, *Technology-Forcing and Federal Environmental Protection Statutes*, 62 IOWA L. REV. 771 (1977).

Our aim in this essay is to reopen the old debate and move it to new ground. Resolution, on the assumption it could ever be within our capacities, is for the present not on our agenda. We hope for now only to reveal and explore the assumptions or premises of the optimistic viewpoint, and to explain why they trouble us. Placed in its largest setting, our argument is indeed about the future of the world — a sure way to lose an audience — but we are content merely to consider its implications for technology at a time of continuing enthusiasm for technological solutions,² and, briefly, its implications for American politics at a time of growing concern about democracy's capacity to cope with modern-day problems.³ We proceed from where we began, by considering technological optimism as a term of art, as an article of faith, and especially as a theory of politics.

I

A technological optimist is not simply a person with unqualified enthusiasm about technological promise. Saint-Simon (1760-1825) was an enthusiast, but he was not a technological optimist as the term is currently used. Saint-Simon, rather, was a utopian who happened to attach his vision to technocratic expertise.⁴ He was the forefather of Technocracy, an active utopian movement in the 1930s and one not entirely dead even today.⁵ Technological optimists are not utopians, but something less — let us say quasi-utopians, after a recent usage (applied to himself) of Robert Dahl's.⁶ Unlike any self-respecting pure utopian, quasi-utopians (and technological optimists) seek not perfection but tolerable imperfection, tolerable because it is better than

2. See, e.g., Huber, *Safety and the Second Best: The Hazards of Public Risk Management in the Courts*, 85 COLUM. L. REV. 277 (1985) (relative benefits and promise of new technology compared to old and to natural background hazards).

3. A concern voiced even by one of democracy's best friends. See, e.g., R. DAHL, *CONTROLLING NUCLEAR WEAPONS* (1985). Dahl questions, but ultimately affirms, democracy's capacity to control nuclear weapons, nuclear waste disposal, recombinant DNA, and problems of modern risk generally. For a contrasting view, see W. OPHULS, *ECOLOGY AND THE POLITICS OF SCARCITY* (1977).

4. On Saint-Simon, see W. OPHULS, *supra* note 3, at 158 ("[O]ne of the earliest prophets of technocracy, [Saint-Simon] believed that it was man's mission to transcend nature with technology. . . . To this end he proposed the creation . . . of a scientific priesthood . . ."). His philosophy is well-summarized in I. BERLIN, *KARL MARX* 66-69 (4th ed. 1978).

5. See W. AKIN, *TECHNOCRACY AND THE AMERICAN DREAM* (1977), on the technocratic movement in the first forty years of the century. Technological utopia suffered an ambivalent reception. For a portrait of the mixed reaction, voiced in American letters, to technological displacement of the pastoral ideal, see L. MARX, *THE MACHINE IN THE GARDEN* (1964).

For evidence that the technocratic viewpoint is still alive, see, e.g., W. OPHULS, *supra* note 3, at 157. See also B. ACKERMAN, *RECONSTRUCTING AMERICAN LAW* 106-10 (1984) (professional hegemony of lawyers is currently being challenged by "technocratic" competitors, e.g., policy analysts and computer scientists).

6. See R. DAHL, *supra* note 3, at 75-90.

anything else they consider attainable though not nearly as good as lots of alternatives that can be imagined.

But technological optimists are also something more than mere believers, or faddists, or techniks.⁷ Their views are rigorously formulated, grounded in an apparent reality, based on knowledge and experience, and artfully defended. There are no crazies among the best of the optimists; they are conservative, respected experts who command enormous authority. They have a very specific position — namely, “that *exponential technological growth* will allow us to expand resources ahead of exponentially increasing demands.”⁸ This is the precise meaning of technological optimism as a term of art.

Some commonplace examples of the optimistic view suggest its range of applications: If the world is running short of food, we can count on technological innovation to increase the productivity of agricultural land and the acreage of arable land itself, through better seeds, better fertilizers, herbicides and pesticides, and better irrigation techniques. If environmental quality is threatened, more effective pollution-control technology can be developed to deal with the problem. If fossil fuels are growing short, technology can reduce the costs of discovery and extraction. It can also provide fuel substitutes, natural or synthetic.⁹

As these examples might suggest, technological growth means technological *advance*; it means breakthroughs — new techniques that get more output per unit of input — rather than simply more of an old technology. Exponential technological growth means continuously compounding technological capacity, a growing accumulation of breakthroughs.

7. The suffix *-nik* “convert[s] a verb, noun or adjective into a colorful pejorative for an ardent lover, cultist or devotee of something . . .” L. ROSTEN, *HOORAY FOR YIDDISH* 233 (Touchstone ed. 1984). *-Nik* implies an uncritical or poorly informed enthusiast, as contrasted to a *maven*, or expert. *Id.* at 207. The more sophisticated of the optimists are *mavens*.

8. W. OPHULS, *supra* note 3, at 116 (emphasis added). This quotation may overstate the optimistic position in one respect, for probably no optimist believes that technological advance can stay ahead of exponentially increasing demand literally *forever*. Rather, the optimistic assessment appears to be that technology can push the day of reckoning far, far, far into the future. As we shall see, however, true optimists do uniformly rely on *exponential* growth in technology to drive the day away, so to this extent Ophuls’ statement is an accurate generalization. For more balanced views of the promise of technological advance — stressing, as we do, crucial questions of institutional capacity — see Brooks, *Can Technology Assure Unending Material Progress?*, in *PROGRESS AND ITS DISCONTENTS* 281 (G. Almond, M. Chodorow & R. Pearce eds. 1982); Rosenberg, *Natural Resource Limits and the Future of Economic Progress*, in *id.* at 301.

9. So great is the power of technological substitution that even Nature’s elemental beauty could be replaced by artifacts — plastic trees, for example — which we could then learn to enjoy as much as we did the original. See Krieger, *What’s Wrong with Plastic Trees?*, 179 *SCIENCE* 446 (1973). Perhaps we might be forgiven a couplet: Only God can make a tree/Except, of course, for technology.

Technological optimism took on its precise meaning, its *exponential* character, as a direct consequence of *The Limits to Growth*,¹⁰ an extraordinarily controversial book published in 1972 and distributed in millions of copies, worldwide, in its first two years.¹¹ The tie between the book and the notion of exponential technological growth is immediately apparent. The authors of *Limits* constructed a simulation model of the world (World 3) and fed into it data based on the assumption that population, industrial production, and pollution would continue to grow exponentially into the future, as they have in the past.¹² The conclusions of this exercise were obviously foregone. Since the world in its physical aspects is finite, exponential growth must eventually hit a limit. The limit was said to be only about a generation away (as of 1972) and would be reached not through a smooth transition but by a crash from good to very bad (poor, crowded, hungry, polluted) conditions. Measures to avert the projected catastrophe would involve (or reflect) radical "value changes" — policies, for example, to reduce birth rates to the point of death rates, to hold capital investment equal to depreciation, to reduce consumption and change its emphasis from material goods to services, to recycle resources¹³ — and require substantial lead times. They had to be implemented quickly in order to escape an otherwise inevitable disaster.

As critics were quick to point out, the authors of *Limits*, for all the attention they gave to exponential growth, neglected it in the case of technology.¹⁴ Take *that* growth into account, and suddenly the future

10. D.H. MEADOWS, D.L. MEADOWS, J. RANDERS & W. BEHRENS, *THE LIMITS TO GROWTH* (1972) [hereinafter cited as *THE LIMITS TO GROWTH*].

11. For a brief, entertaining account of events leading up to and following upon the publication of *Limits*, see M. GREENBERGER, M. CRENSON & B. CRISSEY, *MODELS IN THE POLICY PROCESS* 1-7, 141-46, 158-82 (1976) [hereinafter cited as *MODELS IN THE POLICY PROCESS*]. "Its sales worldwide in its first two years ran into the millions of copies, over 350,000 in the Netherlands alone, where Queen Juliana presided over its public presentation, attended by cabinet members and prominent intellectuals. In Japan it became one of the best selling publications in the country." *Id.* at 2. Our copy of *Limits* says "Second printing before publication 1972."

Limits was introduced to the world at a meeting at the Smithsonian Institution in March 1972. "A flood of phone calls by notables wanting to come to the invitational meeting left the sponsors agape and short of seating space. The privilege of standing in the rear of Smithsonian's Great Hall was gratefully accepted by many who usually make a practice of respectfully declining invitations to academic events." *Id.* (footnote omitted).

12. For summaries of the model, see *MODELS IN THE POLICY PROCESS*, *supra* note 11, at 158-61; Cole, *The Structure of the World Models*, in *MODELS OF DOOM* 14 (H. Cole, C. Freeman, M. Jahoda & K. Pavitt eds. 1973) (published in Great Britain as *Thinking About the Future*). The foregoing also describe World 3's predecessor, World 2, a system dynamics model developed by Jay Forrester. See J. FORRESTER, *WORLD DYNAMICS* (1971).

13. See *THE LIMITS TO GROWTH*, *supra* note 10, at 163-64; *MODELS IN THE POLICY PROCESS*, *supra* note 11, at 161.

14. This was by no means the only criticism directed at *The Limits to Growth*. For an array

looks more promising. Many if not most of the alleged ills of increasing population, production, and consumption, and of apparently diminishing natural resources, can be remedied without drastic measures. Malthusian prospects can be avoided without the basic alterations in social values, organization, and behavior urged by the pessimists. The ultimate problem of "running out" is not really a foreseeable problem at all. It can be forestalled by exponential technological advance.

This is technological optimism in a few superficial lines.

II

Technological optimism is an article of faith as well as a term of art. Simply put, the optimists believe in unending human ingenuity, or at least human ingenuity with no foreseeable limit. They must believe this, because human ingenuity is a necessary, though not a sufficient, condition of technological advance.

The underlying faith of the optimists was not immediately apparent in their responses to *The Limits to Growth*. Carl Kaysen was one of the first to mention exponential technological growth in connection with the book, and Kaysen focused only on some of the intermediate dynamics of technological advance. His review¹⁵ criticized the authors of *Limits* for measuring resources in physical terms, such as tons or acres, thus suggesting the physical finiteness of the earth as the ultimate bound. Kaysen found this misleading. "Resources are properly measured in economic, not physical, terms," he said, because new resources can be created by investment. The problem of scarcity is thus a problem of cost limits rather than physical ones. "The force of rising costs . . . meets the force of advancing technology, which brings down the costs of using existing resources and literally creates new resources by bringing within the bounds of feasibility materials or methods which formerly lay outside it."¹⁶ And technology, like population and industry, "has also been proceeding exponentially." Admitting this into the World 3 model radically alters its outcomes. "The inevitability of crisis when a limit is reached disappears, since the 'limits' themselves are no longer fixed, but grow exponentially too."¹⁷

of views, see MODELS IN THE POLICY PROCESS, *supra* note 11, at 161-76; MODELS OF DOOM, *supra* note 12; ON GROWTH (W. Oltmans ed. 1974).

15. Kaysen, *The Computer that Printed Out W*o*l*f**, 50 FOREIGN AFF. 660 (1972). For a similar early view, see Passell, Roberts & Ross, *The Limits to Growth: World Dynamics; Urban Dynamics*, N.Y. Times, Apr. 2, 1972, § 7 (Book Review), at 1, col. 1.

16. Kaysen, *supra* note 15, at 663.

17. *Id.* at 664.

A paper published just a month later demonstrated Kaysen's point in a rigorous way.¹⁸ Its author altered the world model¹⁹ and fed into it values designed "to conform to the technological optimist's view."²⁰ Even though a rate of technological growth slightly less than exponential was assumed, the results were "exactly what a technological optimist would predict." Rather than disaster, "a 'Utopian' equilibrium is reached."²¹

Work like this suggested the powerful effect that exponentially advancing technology might have, but it hardly established exponential technological growth as a fact. Kaysen simply made undocumented

Figure 1. Sigmoid curve

assertions; Boyd used numbers "invented from whole cloth."²² Subsequently, however, Starr and Rudman²³ offered concrete evidence for the optimistic view of future technological development. They examined "the historical genesis of some of our major technological capabilities — in order to use their general characteristics as a basis for estimating the future production of technological options which may be available to meet the pragmatic needs of the world"²⁴ — and found a promising pattern. While the advance of any given technology usually follows a sigmoid curve (see Figure 1),²⁵ overall growth of the

18. Boyd, *World Dynamics: A Note*, 177 SCIENCE 516 (1972).

19. Boyd focused on Forrester's World 2 model. See note 12 *supra*.

20. Boyd, *supra* note 18, at 517.

21. *Id.*

22. *Id.*

23. Starr & Rudman, *Parameters of Technological Growth*, 182 SCIENCE 358 (1973).

24. *Id.* at 359.

25. Figure 1 is drawn from Starr & Rudman, *supra* note 23, at 360.

technology's "field" is composed of a series of such curves. "Each curve builds on the performance level of the previous generation device. Each new technological step results in eliminating the previous limit and thereby escalates the technological progress of that particular field. Thus the overall growth of a specific technological field often exhibits an exponential pattern."²⁶ Figure 2 illustrates the point.²⁷ Accordingly, Starr and Rudman concluded, the technological component of the World Model "is best represented by an exponential growth function."²⁸

Figure 2. Successive sigmoid curves for a technological field

This seems a bit heroic. The "major technological capabilities" examined by Starr and Rudman were limited to a relative handful (lighting efficiency, operating energy of particle accelerators, power output of basic machines, performance level of computers, aircraft speed, and broadcast frequencies) and a relatively short time span (with the exception of basic machines, 30 to 100 years) — a narrow basis for a sweeping generalization. Moreover, even though a wider historical record might reveal a general pattern of exponential technological growth to date,²⁹ who can say that the past in this respect is prologue? If anything, there are logical reasons to suppose otherwise. Starr and Rudman acknowledged, after all, that a given technology develops

26. *Id.* at 362.

27. Figure 2 is drawn from Starr & Rudman, *supra* note 23, at 360.

28. *Id.* at 364.

29. See, e.g., Hueckel, *A Historical Approach to Future Economic Growth*, 187 *SCIENCE* 925 (1975) (tracing a long history of technological advance, though not necessarily exponential in character).

along a sigmoid curve. If this holds for a *single technology*, why should it not eventually do so for a *set* (or "field") of technologies as well, and if it holds for a set, then why not also, ultimately, for the *set of sets* — in short, for *technology itself*? On this reasoning, the accumulation of sigmoid curves which, piled one upon the other, describes an exponential curve, does so only because we are in the middle — or exponential — range of a larger and longer-term sigmoid curve that might itself flatten out at a time in the future less remote than the optimists suppose.

Kenneth Arrow has said exactly this. "Eternal exponential technological growth," he argued, "is just as unreasonable as eternal exponential population growth." He went on: "But of course exponential technological growth does have the advantage of being consistent with observed facts; if anything, the observed rate of growth of total factor productivity is increasing. I can only conjecture that, as in the case of population, the true law is something like the logistic [sigmoid] curve, but we are still in the early phases, which resemble the exponential."³⁰

The optimists reject this line of reasoning. Technological advance is a product of intellect, and they regard intellect as a resource without limits. Thus Lord Zuckerman complained of *The Limits to Growth* that "the only kind of exponential growth with which the book does not deal, and which I for one believe to be a fact, is that of the growth of human knowledge . . . [T]he tree of knowledge will go on growing endlessly."³¹ This is the most explicit statement of the optimists' article of faith, but Starr and Rudman took the same position implicitly. "Unlike resources found in nature," they said, "technology is a man-made resource whose abundance can be continuously increased," a conclusion they could handily reach by refusing to "assume that knowledge is bounded . . ."³² Hueckel, similarly, found "nothing in our past or present experience which suggests the existence of a limit to man's ability to advance his knowledge . . ."³³

30. Arrow, *Classificatory Notes on the Production and Transmission of Technological Knowledge*, 59 AM. ECON. A. PAPERS & PROC. 29, 34 (1969). Ironically, the closer we are to the upper elbow of a sigmoid curve, the more misleadingly promising will be the projection of past accomplishments into the future.

There is little comfort in Arrow's observation that, just as technology will not grow exponentially forever, neither will population or pollution. The respective curves may not flatten out in a coordinated fashion; pollution could continue at a heady rate even though (or especially because) technological advance has reached a limit. And even if exponential curves flatten out simultaneously, the cause may be sinister — for example, pollution disappearing because it reached a threshold that wiped out life on the planet.

31. Quoted in W. OPHULS, *supra* note 3, at 116.

32. Starr & Rudman, *supra* note 23, at 364.

33. Hueckel, *supra* note 29, at 930.

Arrow, again, would disagree. "There is a limit," he has said, "to what can be learned even with infinitely many opportunities."³⁴

* * *

It is easy enough to see why the debate between the optimists and the pessimists reached a dead end. Repeated assertions of unprovable propositions — that knowledge and its technological products will (will not) continue on their exponential way into the future — don't make for fruitful argument. More promising ground might be opened up by *granting* the optimists their major premise and *assuming* exponential technological growth. It hardly follows that the optimistic outlook is then justified. To the contrary, a heady rate of technological growth could aggravate some of the very problems the optimists count on technological advance to solve. Technology is, after all, a *mixed* blessing, demonstratively capable of producing undesirable as well as desirable consequences. While the optimists concede this point readily enough,³⁵ they display remarkably little curiosity about what the *mixed* consequences of technological development are likely to be. Yet this is the obvious and crucially important question that arises from their concession. (It is also a question that becomes more critical the more technological advance entails risks with catastrophic potential.)³⁶ And it is a question about which exponential technological growth says absolutely nothing.

Other considerations might at least hint at an answer. There are reasons — having to do with individual incentives and with institutional structure — to suppose that the forces behind technological development are systematically biased in the direction of generating and neglecting certain kinds of undesirable consequences, pollution chief among them. In this light, exponential technological growth takes on an equivocal character. Problems as well as solutions can accumulate rapidly, hardly what the technological optimists have in mind.

34. Arrow, *supra* note 30, at 34. The optimists can point to no natural law that requires uninterrupted progress in human ingenuity or knowledge, even if there have been historical trends in that direction. See K. POPPER, *THE POVERTY OF HISTORICISM* 105-19 (1964).

35. See, e.g., Hueckel, *supra* note 29, at 929 ("no doubt that the double-edged sword of technological advance gives man the power either to make life more pleasant or to destroy it"); Kaysen, *supra* note 15, at 667 (discussing "the indirect consequences of technical change, the unanticipated 'side effects' that can sometimes outweigh the benefits"); see also Brooks, *supra* note 8, at 281 (costs and risks of technological advance, including "the proliferation of weapons of mass destruction," which "promises to make even the material progress that has been achieved quite ephemeral and to render ultimate collapse of world civilization highly likely").

36. By catastrophic potential, we mean enormous adverse effects if a risk materializes — effects that are usually irreversible in the short term.

III

The more sophisticated among the optimists are aware of the possibility of systematic bias in the course of technological development. They see that the problem arises from distorted market incentives, and they think that the solution comes in the form of corrective action by government. This is why, at bottom, technological optimism is a theory (an optimistic theory) of politics. To reveal and assess the political theory, we first have to do some economics.³⁷

Markets

An important criticism that the optimists leveled at *Limits* — important because it appears to be justified and because it underlies the argument for technological growth — concerns the book's apparent neglect of market adjustments to scarcity.³⁸ As resources become scarce their prices go up, with two consequences. First, demand generally goes down. Second, the supply of resources (including substitutes) is enlarged or, at the least, there are efforts directed to that end. The promise of higher returns to investment stimulates exploration, extraction, and research and development that were not worthwhile before. Most important to the optimists, higher prices stimulate technical innovation — for example, light bulbs that provide more illumination per unit of energy, cars that get better mileage, pollution-control devices that reduce the unit costs of abatement, advanced means of discovering and exploiting conventional resources or producing synthetic substitutes.

That increasing prices dampen demand is not of itself a perfectly satisfactory answer to the problem of scarcity in the longer run. It is somehow uncomfortable to know, for example, that we shall never really run out of fossil fuels because the last few tons of coal and barrels of oil would be so dear that almost no one would care (could afford) to buy them. Given the dependence of industrial countries on energy, a dependence that reaches into the deepest pockets of poverty, high energy prices could eventually result in problems of distributive justice as catastrophic as the problems of depletion, predicted by *Limits*, that the high prices would forestall. And if we turn from energy to food,

37. The economic theory set out in our discussion is elementary and, no doubt, familiar to some of our readers. We cannot assume, however, that it is familiar to all; and it is important to our discussion of politics. Hence we go through the exercise.

38. See, e.g., Kaysen, *supra* note 15, at 665; Hueckel, *supra* note 29, at 927; Rosenberg, *supra* note 8, at 312. The same theme runs throughout *MODELS OF DOOM*, *supra* note 12. The authors of *The Limits to Growth* claim to have taken market forces into account in their model, but not explicitly. See Meadows, Meadows, Randers & Behrens, *A Response to Sussex*, in *MODELS OF DOOM*, *supra* note 12, at 217, 231-35.

we turn as well to all the countries of the world, not just the industrialized ones. Of itself, the solution of higher prices could be unduly Swiftian.³⁹

Not surprisingly, then, the optimists focus chiefly on the second, and happier, feature of market adjustments to scarcity — the stimulating effect of increased prices on technological advance, which then feeds back into the system and eases the price constraint. Hueckel reviews a rich history of instances and states the familiar generalization: “as existing supplies of nonrenewable resources are depleted, the techniques in use are adapted to that change through the utilization of new methods of extraction and exploration, through the introduction of substitutes for the resource whose supply is diminished, or . . . through the application of techniques to improve the efficiency in use of that resource.”⁴⁰

On what does this optimistic model of market/technology interplay depend? At the least, two important conditions have to be satisfied. First, technology must be *capable* of advance in response to market stimulation. Second, the market must be *capable* of providing stimulation. If it is not, if for some reason the price system does not function smoothly, then the operative mechanism of the market model falls apart (there is “market failure”).

We have conceded, purely for the sake of argument, that the first condition is satisfied; we did so by assuming, with the optimists, not only that technology can and will grow, but that it will do so exponentially. Oddly enough, the optimists concede that the second condition is commonly *unsatisfied*, and in contexts of central importance to their outlook. This is true, at least, of the economists among them. Two of them are worth quoting at some length. Kaysen writes:⁴¹

The social-economic system is *not* self-correcting or self-managing; sustained, self-conscious efforts are necessary to deal with the problems [discussed in *The Limits to Growth*], and they often must be maintained against strong resistance. Two of the authors' three central concerns, population growth and pollution, do indeed present genuinely urgent and difficult problems. A third equally important and difficult one, mentioned in “Limits,” but only in passing, is the assessment of the indirect consequences of technical change, the unanticipated “side effects” that can sometimes outweigh the benefits. Present social mechanisms are not adequate for coping with any of the three, and the kinds of changes required to do so more effectively meet strong opposition at every level, from that of the individual family to organized interest groups and gov-

39. See, e.g., Brooks, *supra* note 8, at 289-91.

40. Hueckel, *supra* note 29, at 927.

41. Kaysen, *supra* note 15, at 667.

ernments. From one point of view, all three problems can be seen as examples of "external effects," where costs and benefits of particular actions are not borne by the primary actors and thus fall outside the reach of the price system as it usually functions and the control of the incentives and adjustment mechanisms it provides.

Hueckel elaborates as follows:⁴²

Unfortunately, the common characteristic of most of the problems facing society today is that they relate to commodities or resources for which the unregulated marketplace generates no price information. This failure of the market to generate such information is the result of the lack of well-defined property rights in certain resources Thus, because no one owns the air over a city, no one charges the local manufacturing plant a price for the privilege of using that air as a waste receptor, nor are the residents of the city charged for the pollutants emitted from their automobiles. To make matters worse, those resources are consumed collectively; consequently, even if a price could be set there would be no inducement for consumers to pay unless there was some element of compulsion — a characteristic not found in goods normally traded in the marketplace. . . .

On the other hand, even if the residents of a community were charged a price for the privilege of using the air as a receptor for the wastes from their automobiles, there would be little inducement for an individual to pay since he could not be excluded from such use.

The solution to market failure is taken to be government intervention — as Kaysen puts it, "a set of supplementary adjustment mechanisms and incentive systems which can guide the relevant actors to socially more desirable choices";⁴³ or, in Hueckel's more explicit but rather inelegant terms, "well-considered social policies in which the government intervenes in the marketplace in such a way as to cause it to generate appropriate price signals to both producers and consumers in order to direct the allocation of inventive resources to the solution of those problems [discussed in *Limits*]." ⁴⁴

Starr and Rudman put the point differently, perhaps because they are not economists. They neglect the problem of market failure, but they do acknowledge that constructive technological advance is "a sociological matter" and depends on "the existence of social institutions structured to advantageously exploit" technological opportunities. In their opinion, technological development is in important part a function of "[s]ocietal expectations and objectives," for these "determine the allocation of resources among all of the technological . . . activities within our society" — they establish the "payoff factor" that encour-

42. Hueckel, *supra* note 29, at 930.

43. Kaysen, *supra* note 15, at 667.

44. Hueckel, *supra* note 29, at 930.

ages technological advance. Social expectations and objectives, in turn, are "integrated by the political decision-making process" and "determine the detailed allocations for individual activities such as technological fields."⁴⁵

Politics

So it comes down to politics. Unhappily, however, the identical conditions that account for market failure suggest the heavy possibility of political difficulties as well. The optimists, because they neglect to pursue their economic insights into the political arena, overlook or understate this crucially important point.⁴⁶ To bring it into view here requires, first, a fuller account of market failure than the one sketched for us thus far; and, second, an application of that account to the related problem of political failure.

As mentioned earlier, technological development can entail both desirable and undesirable consequences. The consequences might be entirely (or largely) "internal," affecting only the volitional producers (and their employees) and consumers (users) of the technology in question, or they might be significantly "external," the so-called side effects, good and bad, that fall on third parties who choose neither to produce nor to use a technology. The market, we know, tends to work smoothly in the first case, but it balks in the second. Both sides of this generalization can be illustrated with a few homely examples.

Imagine an automobile manufacturer, *M*, and a series of hypothetical technological advances. The first advance, *A1*, would reduce the amount of energy needed to run *M*'s production line but at the same time make the line slower, or the working conditions of *M*'s employ-

45. Starr & Rudman, *supra* note 23, at 359-61. Sam Peltzman confirms that these views of governmental correctives are representative rather than exceptional. He describes the response of the economics fraternity, discussed in the text following note 54 *infra*, as having its genesis "in a growing disenchantment with the usefulness of the traditional role of regulation . . . as a *deus ex machina* which eliminated one or another unfortunate allocative consequence of market failure." See Peltzman, *Toward a More General Theory of Regulation*, 19 J. L. & ECON. 211, 211 (1976).

46. Kaysen, *supra* note 15, at 667-68, acknowledges the difficulties of the political task, but leaves them unattended. Starr & Rudman, *supra* note 23, at 364, see social resources and expectations as "key parameters to technological growth," but conclude that "their combined effects can be expected to continue technology's historical exponential growth." They hold the unexamined faith that these combined effects will drive technology in appropriate directions. Hueckel, *supra* note 29, simply begs the question. The problems raised by *The Limits to Growth*, he says, "require imaginative and well-considered social policies in which the government intervenes . . . , but once the policies are implemented, the record of past technological change strongly suggests that future technology will respond." *Id.* at 930 (emphasis added). Once the policies are implemented, we suppose that's so.

For bleaker outlooks on political and institutional capacity, reported by observers basically sympathetic to the optimistic message, see Brooks, *supra* note 8, at 298-300; Rosenberg, *supra* note 8, at 317-18.

ees less safe. Advance *A2* would provide *M* with a new and inexpensive synthetic material for vehicle bodies, but drivers would be endangered because the new material is known to stand up poorly in collisions. Advances *A3* and *A4* would improve the fuel economy of *M*'s vehicles, the first by modifications that increase engine efficiency but also cost, the second by modifications that hold engine cost constant but increase engine pollutant emissions. Assuming self-interested actors (as the optimists implicitly do), market forces will likely induce individual decisions consistent with society's interests in cases *A1*, *A2*, and *A3*, but not in case *A4*.

In case *A1*, the benefits of energy savings but also the costs of a slower or less safe production line would be brought to bear on *M*'s cost-benefit calculations. Part of this is obvious. *M* would compare its gains (*G*) in reduced energy costs to its losses (*L*) in production time and adopt *A1* only if $G > L$. Assuming, for purposes of this example, the absence of any side effects of energy production or consumption, the decision made by *M* would be best not only for it, but for society as well. A part of society's energy resources would be saved for alternative uses only if the part of society's valuable stock of time lost in the process (measured in increased prices for *M*'s vehicles) were worthwhile. *M*'s private and utterly self-interested decision would promote a socially optimal result because all of the costs and benefits of the decision would be internal to (felt by, considered by) *M*; *G* and *L* would reflect social as well as private gains and losses. The same holds if adopting *A1* would mean a more dangerous, rather than a slower, production line. Here the process of transacting in the market would bring home to *M* the costs of choosing *A1*. If *A1* made working conditions less satisfactory, *M*'s employees would insist on offsetting compensation, or take their labor elsewhere.⁴⁷ Again, *M* would be forced to compare social gains and losses. The level of danger in society would be increased only if the costs of doing so were more than offset by the benefits of saving energy.

Cases *A2* and *A3* also involve market transactions that internalize costs and benefits on the relevant decisionmakers and thus promote socially optimal results. In case *A2*, *M* would be forced to compare the social benefits of cheaper vehicles (measured in more sales and more profits) to their social costs (measured in losses of sales and prof-

47. The point is somewhat contentious; not all economists agree that the labor market works so smoothly in exacting wage premiums for occupational risk. The disagreement, however, is unimportant to our example, the point of which is simply to show how transactions — between employers and employees, for instance — might help internalize effects that would otherwise be ignored by a relevant party.

its as consumers learned that an *A2* car is dangerous).⁴⁸ In case *A3*, consumers would compare what they save in fuel to what they lose by having to pay more for an *A3* car and respond accordingly; their response, in turn, would affect *M*'s calculations. Obviously, *M* would produce the *A3* model only if the present value of the fuel savings over the life of the model were larger than the vehicle's higher cost — a cost that would be higher because inputs of other scarce, valuable resources would have to be increased in order to realize the savings in fuel resources.

What of case *A4*? Self-interested consumers would be attracted to the *A4* model because it economizes on fuel; the attraction, translated into heightened demand, would feed back into *M*'s calculations and encourage it to produce the new vehicle. The pollution costs of increased emissions, however, would likely be ignored by *M* and its consumers alike, because the pollution costs *to them* would be trivial compared to their private gains; most of the costs would fall on society at large. The aggregate pollution costs to society at large could also be trivial, of course, or in any event less than the aggregate benefits of fuel savings achieved by *A4*. But the costs could just as well be very high, such that $G < L$ from society's perspective. Still consumers would be inclined to purchase, and *M* inclined to produce, vehicles that represented a net social loss, because pollution costs would be excluded from their calculations of private costs and benefits. The important point for now, however, is not how total social *G* and *L* would compare, but rather that *no comparison* would be made. Benefits would be considered, because they are internal to *M* and its consumers; the external costs of pollution, on the other hand, would be neglected by these self-interested actors. Externalities, in short, illustrate a classic instance of market failure.

In principle, all the consequences of any given technological change could be internalized through market forces; in practice, however, this is virtually impossible in the case of widespread, collective consequences like environmental pollution. Suppose *M* decided to manufacture the *A4* model even though it would generate external pollution costs far in excess of energy savings.⁴⁹ Since the victims of pollution would stand to lose more than *M* would gain, it would be in their aggregate best interest to organize among themselves, raise

48. The point is again contentious; some observers believe that consumer awareness of risk is insufficient to induce appropriate decisions through the market. Our response is the same as in note 47 *supra*.

49. This is the expected decision absent regulatory constraints, and the decision commonly observed throughout the history of pollution control efforts in the United States. See J. KRIER & E. URSIN, *supra* note 1, at 280-83.

money, and offer *M* an acceptable inducement not to manufacture the *A4*. But successful organization would obviously be difficult, if not impossible. Getting all or a significant portion of the members of a large group to cooperate is not a simple matter, especially because members would tend to free ride. Each would be likely to withhold a contribution to the organizational effort, reasoning that if the other pollution victims gave enough to induce *M* to forgo the *A4*, pollution would be diminished and everyone, even those who contributed nothing, would be better off. This "collective goods effect," alluded to earlier by Hueckel, arises whenever it is infeasible to exclude noncontributors from the benefits of productive activity.

Most of the side effects of technological development are side effects precisely because the market fails to make them central. As a consequence, the market's system of incentives is biased. Internal costs and benefits tend to be considered, external ones ignored. Autonomous decisionmakers in the marketplace feel little impulse to produce external benefits or to avoid producing external costs, because doing so would generally impose a cost on the decisionmaker that could not be recaptured through the market. This is not to say that self-interested actors never produce external benefits (or control external costs). On occasion, a privately interested decision may generate external benefits incidentally, as where a change in manufacturing processes, undertaken because it reduces a firm's costs, also happens to reduce its pollution. But these are maverick cases; we cannot depend on them generally.

The point, in short, is that market forces can bias each link in the chain of decisionmaking about technology, from research and development to production and consumption and patterns of use.⁵⁰ In this light, exponential technological growth looks like an aggravating rather than an ameliorating factor, for it could promote exponential growth in social costs. So far as the market is concerned, undesirable consequences of a collective kind — because they tend to be ignored — could multiply as rapidly as desirable ones. Indeed, because market forces tend to disregard these consequences and their control, the bad could plausibly outpace the good.⁵¹

50. On the tendency of unconstrained technological change to increase environmental and other external costs, see T. PAGE, CONSERVATION AND ECONOMIC EFFICIENCY 91, 96-97, 177-78 (1977).

51. In some cases, of course, market forces can correct their own shortcomings and stimulate the provision of remedies. But, for all the reasons that generate market failure in the first instance, we would anticipate market remedies only where benefits are private, as in the case of home water purifiers or air pollution face masks. Market cures are theoretically possible in some cases (air pollution face masks again), but they promise a quality of life virtually as dismal as that predicted in *Limits*. The possibility of market correctives also requires a dynamic process in

Unless, of course, the government steps in. But the difficulty now is that *government* measures to avoid collective bads and provide collective goods (through advances in pollution-control technology, for example) are *still* collective. So why can we count on the government to do the right thing?

No one denies that the government is capable, in principle, of dealing with the problem of collective effects, but then so too is the market — in principle. The question is whether the government can be counted upon, in practice, to provide incentives that the market, in practice, cannot. If the mechanisms of governmental intervention regarding technological development are biased — in much the same fashion and much the same direction as market mechanisms — by the presence of transaction or organization costs, then government intervention is not the easy corrective that the optimists imagine.

On one view of the political world, governmental mechanisms are not biased — not, at least, the way market mechanisms are. According to this “public interest” perspective, markets are private and biased toward private interests, whereas governments are public and biased toward public interests. Under appropriate conditions, the self-seeking behavior central to the idea of market activity promotes the greater good. Under other conditions (market failure), self-interested behavior is socially counterproductive; at such times, according to public interest theory, the government intervenes with corrective measures.⁵²

Public interest theory provides obvious support for the optimistic outlook. Unfortunately, however, its rosy picture is widely regarded by contemporary observers as an inaccurate depiction of political real-

which subsequent trials are capable of eliminating the adverse effects of prior errors. The catastrophic potential of developing technologies, however, suggests irreversible effects not susceptible to correction by future adjustments.

It is unlikely that the courts can do much to correct the market deficiencies in question, for at least two reasons. First, the structural impediments created by collective effects hinder litigation, just as they do a smooth market. *See generally* R. STEWART & J. KRIER, *ENVIRONMENTAL LAW AND POLICY* 255-89, 314-24 (2d ed. 1978). Second, the barriers to litigation vary with the nature of the particular problem, and the evidence is that the resulting differential effects often work *against* appropriate technological advance. *See* Huber, *supra* note 2. In short, at best the courts cannot do much to curb undesirable technological trends; at worst they can aggravate them.

52. *See* Levine, *Revisionism Revised? Airline Deregulation and the Public Interest*, 44 *LAW & CONTEMP. PROBS.*, Winter 1981, at 179, 179 n.1, for a statement of the public interest view and citations to the literature advancing it.

There are ongoing efforts to revise public interest theory in light of such recent events as deregulation and environmental and consumer legislation. *See, e.g.*, Kalt & Zupan, *Capture and Ideology in the Economic Theory of Politics*, 74 *AM. ECON. REV.* 279 (1984); Levine, *supra*. It should be noted that the revised theory is revised theory as well, admitting a concern for the wider public interest into the list of motivations that drive political actors, but not assigning it a dominant role.

ity. The theory has two chief difficulties. First, it confronts a large body of contrary evidence.⁵³ Second, the theory does not explain the connection between the public interest and governmental activity. To make the theory work, one would have to assume, counterfactually and counterintuitively, that voters regularly behave altruistically or that politicians collude, and on this latter assumption it is not the public interest that would be served by intervention, but only the politicians' view of what the public interest should be.⁵⁴

Perhaps a third difficulty with the public interest theory of government intervention is that alternative views are more convincing both as stories and in light of the evidence, which is not to say that the stories please us or that the evidence is uniformly consistent with them. The thrust of the alternative views can be gathered from the "capture" metaphor commonly used in speaking of them as a whole. Capture theory in its modern form is essentially an economic theory of intervention, but it appears to be a well-established paradigm of contemporary political theory as well.⁵⁵

Central to capture theory is the notion of a political *marketplace* largely populated by self-interested actors — politicians and voters — who seek to advance their welfare by holding office (politicians) or by inducing officeholders to enact favorable policies (voters). Politicians seeking to get, hold, or improve positions succeed if they can gather the support of enough voters, whose support, in turn, is influenced by what the politicians (promise to) deliver by way of policy. Voters attempt to influence political outcomes not only by voting but also by campaigning, lobbying, and contributing financially to politicians and political causes. Indeed; voting is probably the least effective way, overall, to influence governmental policies: each voter has only one vote and can vote for only one candidate for each office, even though no one candidate is likely to share all of the voter's views on all of the issues that matter. By and large, voters are thought to choose among candidates on the basis of specific, concentrated (i.e., income-enhancing) effects of alternative political programs, as opposed to more general, diffuse effects. Auto workers, for example, will tend to support politicians who are friendly to the auto industry, notwithstanding that their programs might imply more air pollution; employees of the chemical industry will likely be more concerned with jobs and job

53. See, e.g., Levine, *supra* note 52, at 179-80; Posner, *Theories of Economic Regulation*, 5 BELL J. ECON. & MGMT. SCI. 335, 336-37 (1974).

54. Posner, *supra* note 53, at 340-41.

55. We draw here from Noll, *The Political Foundations of Regulatory Policy*, 139 J. INST. & THEOR. ECON. 377 (1983).

safety than with the impact of chemicals on the larger environment and will express their political preferences accordingly; by and large, employees of defense contractors will favor hawks, despite the impact of an arms race on the budget, inflation, income taxation, and world peace. This pattern is especially likely given that voters are usually best informed about specific effects and thus inclined to let their views on specifics, such as their jobs, incomes, and immediate lives, dominate at the polling place. Politicians respond accordingly, "claiming credit for income-producing actions of government when communicating with the lucky winners."⁵⁶

An important exception to these generalizations arises when some political issue, even though its resolution will have a diffuse rather than a concentrated or specific effect, becomes salient — implying that each voter has a large stake in the issue's resolution and that each voter will be relatively well-informed about the issue because it becomes the subject of regular discussion. Absent salience, however, specific effects will be the important ones, with obvious consequences. Policies with large but diffuse benefits, and smaller but concentrated costs, will be vulnerable in the electoral process.⁵⁷

Political activities other than voting are likely to have the widest and also the most selective impact on policy formulation. One can hope, by lobbying, by contributing to lobbies, or by supporting campaigns (including the campaigns of political entrepreneurs seeking to make some latent issue salient), to influence voters' choice of candidates and politicians' choice of policies. But now the analogy of politics to markets becomes more painfully pointed. Effective lobbying and effective campaigns require significant effort. The total costs of these sorts of political activity will commonly exceed their benefits to any one individual, even though the costs are less than benefits in the aggregate. This is almost sure to be the case if benefits are diffuse. Thus a number of individuals must contribute; interest groups must be formed if there is to be any hope to capture the policy process. Yet the policies of importance here will generally have diffuse collective effects. Because the effects are diffuse, any given individual is unlikely to be inclined to make a large contribution to their realization. Because the effects are collective, any given individual is unlikely to make *any*

56. *Id.* at 389.

57. *See, e.g., id.*: "[M]ost regulatory policies are narrow and have a small per capita impact on citizens. The per capita stakes of people in a regulated industry are much higher. Consequently, when the generic issue of regulatory policy is not salient, the income side of regulatory policies will have more electoral significance than the correction of market failures." Of course, a very large number of voters with a shared view on some issue can have electoral influence even without being explicitly organized.

contribution, for if the policies become reality, noncontributors cannot be excluded from the benefits.⁵⁸

We are back, then, to the problem of free riding first encountered in the conventional — not political — market setting. The problem is not symmetrical; it does not disadvantage all potential interest groups equally. Large groups will usually confront greater organizational burdens than smaller ones, whose members will each have a relatively bigger stake, will likely be better informed, and will be more susceptible to pressures to support the group program. Groups supporting policies with diffuse benefits will usually have more difficulty than those opposed to policies with concentrated costs, especially when benefits are collective.⁵⁹ Combining these observations, we see that large groups seeking policies that would generate diffuse collective benefits (like pollution control from the standpoint of victims) are disadvantaged relative to small groups opposed to policies that would impose concentrated costs (like pollution control from the standpoint of industries).⁶⁰ The generalization applies to all forms of nonvoting political activity, whether campaigning, contributing, lobbying, or participating directly in policymaking. Its implications are apparent. Governmental intervention to stimulate appropriate technological activity with regard to pollution and similar problems is likely to prove wanting in quantity and quality alike.⁶¹

The last decade and a half of environmental programs, not to men-

58. Where the adverse effects are latent — materializing, if at all, only in the future — those most likely to bear the costs of a current decision to develop a technology may not be represented at all. Even more than in the typical situation of collective benefits, future generations must rely on the altruism of others to address their concerns.

59. See generally M. OLSON, *THE LOGIC OF COLLECTIVE ACTION* (rev. ed. 1971). Noll, *supra* note 55, at 392, observes that the targets of a regulatory program might avoid free riding problems; each target firm views its political contributions as an essentially private arrangement. In any event, firms in an industry vulnerable to regulation might find it problematic to abstain from joining organizations (such as trade associations) that lobby for association interests. Some significant benefits of association can be withheld from nonmembers; even as to the apparently collective benefits of association political activity, each firm in an industry usually has one or more unique characteristics, and these make it possible for association lobbying efforts to be tailored to exclude the interests of nonmembers. This makes free riding risky, rather than free, and thus reduces its incidence. See Stigler, *The Theory of Economic Regulation*, 2 *BELL J. ECON. & MGMT. SCI.* 3 (1971).

60. Of course, large groups might enjoy one feature of size that gives them a relative advantage in fund raising. Even if only a small percentage of a large group's membership gives only a small amount per capita, the total sum could equal or exceed the war chest of a small group whose members contribute handsomely. See Posner, *supra* note 53, at 349.

61. As Roger Noll has emphasized in commenting on an earlier draft of this essay, the observation in the text holds as well with regard to governmental programs designed not to ameliorate the negative effects of some technology already in place, but rather to affect the design and selection of technologies in the first instance by requiring technology assessments, by setting performance criteria for new technologies, or by insisting on demonstration projects as a prerequisite to putting a technology on line.

tion deregulation and a raft of consumer measures, might be taken to suggest that this concern is unwarranted. Granted, some observers see these developments as an apparent contradiction of capture theory,⁶² but others account for them in a manner entirely consistent with it. One study in this vein relies on such factors as the salience of environmental issues in recent years, the efforts of aspiring politicians like Senator Muskie, and some features of federalism to make out a plausible case.⁶³ Russell Hardin⁶⁴ takes a somewhat different approach, suggesting a variety of ways in which conventional wisdom about the strategic disadvantages of large groups seeking diffuse collective benefits is overgeneralized. Using the Sierra Club and other environmental organizations as illustrations, Hardin points out how such groups sometimes manage to achieve their ends. A large organization, for example, might be small in the sense that some critical subgroup within it, with organization costs corresponding to its size, will be able to do the larger group's work. Indeed, the subgroup might be the only part of the membership interested in collective goods. Most members of the Sierra Club may join purely for the pleasure of hiking with kindred spirits, but all of them pay dues. A subgroup interested in conservation can tap these dues, in essence taking a free ride on the membership's funds.

Another of Hardin's illustrations pictures a subgroup of one, but one who happens to be *privately* interested in a large group's public goals and sufficiently endowed (like a Rockefeller) to realize private objectives by helping the group achieve its public ones. Here the collective benefit is essentially a by-product of privately interested activity.⁶⁵ But Hardin recognizes that the exceptional achievements of groups like the Sierra Club *are* exceptional. "The logic of collective

62. See, e.g., Posner, *supra* note 53, at 353; Levine, *supra* note 52, at 180.

63. See Elliott, Ackerman & Millian, *Toward a Theory of Statutory Evolution: The Federalization of Environmental Law*, 1 J. LAW, ECON. & ORG. 313 (1985). Among other things, Elliott et al. account for our relative success in controlling motor vehicle pollution, notwithstanding the difficulties discussed in the text at notes 56-61 *supra*. For a record of the years of debate and delay preceding significant motor vehicle pollution control legislation, see J. KRIER & E. URSIN, *supra* note 1, at 77-89.

64. R. HARDIN, *COLLECTIVE ACTION* (1982). Hardin's book is an effort to understand and account for an apparent irony — that instances of successful collective action have become commonplace since about the time of Olson's *The Logic of Collective Action*, *supra* note 59. See R. HARDIN, *supra*, at xiv.

65. Hardin provides a vivid example of collective benefits emerging from self-interested conduct:

[C]onsider the actual case of billionaire Howard Hughes, whose tastes ran to watching westerns and aviation movies on television from midnight to 6:00 a.m. When he moved to Las Vegas where the local television station went off the air at 11:00 p.m., his aides badgered the station's owner to schedule movies through the night until the owner finally challenged a Hughes emissary: "Why doesn't he just buy the thing and run it the way he wants

action," he concludes, "is . . . unquestionably successful in predicting negligible voluntary activity in many fields, such as the contemporary environmental movement. . . . [E]nvironmentalists contribute woefully little to their cause given the enormous value to them of success and given the repeated survey results that show the strong commitment of a large percentage of Americans to that cause."⁶⁶

Capture theory, then, does not imply an utter absence of appropriate intervention, much less an absence of intervention altogether. What it implies, rather, is that large groups seeking diffuse collective benefits are relatively disadvantaged, though aided occasionally by salience, political entrepreneurship, and the like. Capture theory also suggests that programs that appear to reflect the collective interest might instead be the compromised products of small group influence. Public works programs for sewage treatment provide one example;⁶⁷ the requirement of scrubbers for treatment of sulfur oxides provides another;⁶⁸ national defense provides a third. This quintessential collective good provokes concern not because it is undersupplied, but because it is alleged to be oversupplied at the behest of powerful private interests — like the defense industry.

IV

Technological optimism is a necessarily contingent point of view. The optimistic outlook depends on a package of considerations none of which is sure to materialize and one of which — exponential technological growth — turns out to be not nearly so climactic as the optimists imagine. Technology can generate bad consequences as well as good, and exponential growth says nothing, of itself, about what the mix of bad and good will be. If anything, our discussion suggests that technological growth could well lead to the bad outpacing the good. The optimists either overlook this point or reflect an unarticulated willingness to gamble that government intervention will provide appropriate constraints, despite the warnings of the capture theory of politics.

to?" Hughes obliged, paid \$3.8 million for the station, and ran movies until 6:00 a.m. The potential audience for these movies was a quarter of a million people.

R. HARDIN, *supra* note 64, at 42. Not only was this action appropriate from a comparison of personal costs and benefits, it conferred substantial external benefits on all other television-owning aficionados (cowboyniks?) of late night westerns.

66. *Id.* at 11.

67. Weingast, Shepsle & Johnsen, *The Political Economy of Benefits and Costs*, 89 J. POL. ECON. 642 (1981).

68. B. ACKERMAN & W. HASSLER, *CLEAN COAL/DIRTY AIR* (1981). See generally R. CRANDALL, *CONTROLLING INDUSTRIAL POLLUTION* 110-30 (1983) (distorting effects of regional politics of federal air pollution legislation).

Of course, even if capture theory depicts today's dominant political reality, one can readily enough take a dynamic view and imagine the evolution of incentives and structures better adapted to realizing the collective good through technology. Indeed, adaptation might grow increasingly likely as present biases in the course of technological development aggravate environmental conditions. As the point of crisis approaches, concerns could become so salient as to move politics toward reform. Altruistic individuals and institutions might gain ascendancy, as some believe occurred at the founding of our Republic.⁶⁹

But this is the late twentieth century, not the late eighteenth. The problematic side of modern technology is known to be troublesome in ways not recognized two hundred years ago. Several features in particular deserve mention. One is latency — where effects are manifested long after the initiation of their cause — coupled with irreversibility, or a resistance to correction or cure. Another is the so-called zero-infinity characteristic so common to modern technological risks; the label refers to effects that are extraordinarily unlikely to occur, but catastrophic if they do.⁷⁰ To rely on salience or any other reactive political strategy in the face of such features is obviously troublesome. By the time a latent problem became salient, for example, it could well be too late for cure; carcinogens and policies to control them provide a classic example here. The suddenly salient but incurable problem, moreover, might be terminal or nearly so; here the example is nuclear weapons and the development of deterrence strategy.

69. See H. COMMAGER, *THE EMPIRE OF REASON* 162-75 (1977). Commager contends that, far from self-interest, the creation of an American community evolved from a shared communitarian spirit: "It came from the people; it was an act of will." *Id.* at 163. Only the most venal engaged in the politics of special interest:

Here it was the farmers and frontiersmen, the fishermen and woodsmen, the shop keepers and apprentices, the small-town lawyers (there were no barristers), the village clergy (there were no bishops), the country schoolteachers (there were no dons) who provided the warp and the woof for the fabric of nationalism. Only the large slaveholders represented the kind of widespread and continuous special interest that sustained the State or the Monarch in Europe, and these, as it turned out, contributed as much to the disintegration of the nation as to its nourishment.

Id. at 173-74.

Some observers believe that present-day political activity is not so self-interested as our reading indicates. See, e.g., Verba & Orren, *The Meaning of Equality in America*, 100 POL. SCI. Q. 369, 371-72 (1985). In the opinion of Verba and Orren, "the ubiquity of collective action in the United States suggests that people in fact pursue goals that transcend their self-interest." *Id.* at 372. They do at times, of course, but the idea that altruism has a general, regular, and dominant influence is implausible — especially in light of obviously desirable collective action that does *not* occur. The essentially self-interested account (the effects of salience considered) strikes us and many other observers as the more convincing, if not nearly so happy, story.

70. On latency, see Brooks, *supra* note 8, at 291-92. On latency, irreversibility, and the zero-infinity problem, see Page, *A Generic View of Toxic Chemicals and Similar Risks*, 7 ECOLOGY L.Q. 207 (1978).

Unfortunately, American politics, in the pertinent realm of environmental problems at least, has practiced its own brand of reactive policymaking, adopting an essentially trial-and-error approach to intervention and relying on episodic crises as virtual godsend that resolve uncertainty and overcome political inertia.⁷¹ The approach works well enough, in fact it is exemplary, in the case of conventional problems (that is, problems that do not threaten latent, irreversible, and possibly catastrophic effects). It can hardly be recommended, however, in the unconventional settings under consideration here, where false technological steps become ever more capable of teaching lessons that are uninteresting only because they tell us too much, and too late.

The gambles implicit in the optimistic outlook are made tempting by a variety of considerations, some of them of indisputable allure. There are the optimists themselves, whose credentials and authority take on all the more weight because they stand behind a story each of us wishes to hear. There is a history of many technological successes and few tragic failures, resulting in the concern that a cautious attitude about technology might be *too* cautious and leave us much the worse off on balance.⁷² There is the matter of remoteness, probabilistic and temporal alike: many conceivable technological risks are unlikely to materialize; if they do, the losers are apt to be the members of future generations, whereas the winners populate the present.

But in the end, of course, these considerations only aggravate an already serious situation. They distract attention from the un-easy political theory that underlies the optimistic position. Reveal that theory and its problems, and suddenly the basis for optimism becomes

71. See J. KRIER & E. URSIN, *supra* note 1, at 251-307. In essence, the pages cited describe a process of interest group pluralism augmented by a kind of incremental, trial-and-error decision-making that Charles Lindblom has aptly labeled "muddling through." See Lindblom, *The Science of "Muddling Through,"* 19 PUB. AD. REV. 79 (1959); Lindblom, *Still Muddling, Not Yet Through,* 39 PUB. AD. REV. 517 (1979). On the shortcomings of interest group pluralism and muddling in the context of problems like those discussed in the text, see R. DAHL, *supra* note 3, at 8-16. Given that the decisionmaking features identified by Lindblom and Dahl characterize much of modern American democracy, one has to wonder whether the democratic form represents a viable politics. This issue is explored at length by Dahl, and far more pessimistically by W. OPHULS, *supra* note 3, at pt. II.

72. See, e.g., Huber, *supra* note 2. At the extreme, issues about technological development might display zero-infinity characteristics of a roughly symmetric sort: technological advance might (improbably) result in catastrophic consequences, but technological standstill might as well. Herman Kahn suggested, for instance, that commonplace good technologies, such as aspirin or the automobile, would never have been approved if their introduction had been preceded by today's process of technology assessment. He argued that current assessment methodology places a premium on the avoidance of clear dangers — bleeding stomachs or automobile accidents — and discounts potentially greater but less readily identifiable dangers that would materialize with technological stasis. See H. KAHN, W. BROWN & L. MARTEL, *THE NEXT 200 YEARS* 167-73 (1976).

insecure, even granting whatever grand assertions the optimists wish to make about pure technological potential in an ideally governed world.⁷³ The disservice of technological optimism is its implicit, unexamined claim that engineering can rise above politics.

73. See, e.g., Brooks, *supra* note 8, at 298-300; Rosenberg, *supra* note 8, at 317-18.