

## REFERENCES

- P. Dasgupta and G. Heal, "The Optimal Depletion of Exhaustible Resources," *Rev. Econ. Stud.*, 1974.
- F. H. Hahn, "Equilibrium Dynamics with Heterogeneous Capital Goods," *Quart. J. Econ.*, Nov. 1966, 80, 633-646.
- H. Hotelling, "The Economics of Exhaustible Resources," *J. Polit. Econ.*, April 1931, 39, 137-175.
- W. D. Nordhaus, "The Allocation of Energy Resources," *Brookings Papers on Econ. Activ.*
- and J. Tobin, "Is Economic Growth Obsolete?" in National Bureau of Economic Research, *Economic Growth*, 50th Anniversary Colloq. V, New York 1972.
- K. Shell and J. E. Stiglitz, "The Allocation of Investment in a Dynamic Economy," *Quart. J. Econ.*, Nov. 1967, 81.
- R. M. Solow, "Intergenerational Equity and Exhaustible Resources," *Rev. Econ. Stud.*, 1974.
- J. E. Stiglitz, "Growth with Exhaustible Natural Resources," *Rev. Econ. Stud.*, 1974.
- M. Weinstein and R. Zeckhauser, "Use Patterns for Depletable and Recyclable Resources," *Rev. Econ. Stud.*, 1974.

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## Sustainability: An Economist's Perspective

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This talk is different from anything else anyone has heard at Woods Hole; certainly for the last two days. Three people have asked me, "Do you plan to use any transparencies or slides?" Three times I said, "No," and three times I was met with this blank stare of disbelief. I actually have some beautiful aerial photographs of Prince William Sound that I could have brought along to show you, and I also have a spectacular picture of Michael Jordan in full flight that you would have liked to have seen. But in fact I don't need or want any slides or transparencies. I want to talk to you about an idea. The notion of sustainability or sustainable growth (although, as you will see, it has nothing necessarily to do with growth) has infiltrated discussions of long-run economic policy in the last few years. It is very hard to be against sustainability. In fact, the less you know about it, the better it sounds. That is true of lots of ideas. The questions that come to be connected with sustainable development or sustainable growth or just sustainability are genuine and deeply felt and very complex. The combination of deep feeling and complexity breeds buzzwords, and sustainability has certainly become a buzzword. What I thought I might do, when I was invited to talk to a group like this, was to try to talk out loud about how one might think straight about the concept of sustainability,

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what it might mean and what its implications (not for daily life but for your annual vote or your concern for economic policy) might be.

Definitions are usually boring. That is probably true here too. But here it matters a lot. Some people say they don't know what sustainability means, but it sounds good. I've seen things on restaurant menus that strike me the same way. I took these two parts of a definition from a UNESCO document: "... every generation should leave water, air and soil resources as pure and unpolluted as when it came on earth." Alternatively, it was suggested that "each generation should leave undiminished all the species of animals it found existing on earth." I suppose that sounds good, as it is meant to. But I believe that kind of thought is fundamentally the wrong way to go in thinking about this issue. I must also say that there are some much more carefully thought out definitions and discussions, say by the U.N. Environment Programme and the World Conservation Union. They all turn out to be vague; in a way, the message I want to leave with you today is that sustainability is an essentially vague concept, and it would be wrong to think of it as being precise, or even capable of being made precise. It is therefore probably not in any clear way an exact guide to policy. Nevertheless, it is not at all useless.

Pretty clearly the notion of sustainability is about our obligation to the future. It says something about a moral obligation that we are supposed to have for future generations. I think it is very important to keep in mind—I'm talking like a philosopher for the next few sentences and I don't really know how to do that—that you can't be morally obligated to do something that is not feasible. Could I be morally obligated to be like Peter Pan and flap my wings and fly around the room? The answer is clearly not. I can't have a moral obligation like that because I am not capable of flapping my arms and flying around the room. If I fail to carry out a moral obligation, you must be entitled to blame me. You could properly say unkind things about me. But you couldn't possibly say unkind things about me for not flying around the room like Peter Pan because you know, as well as I do, that I can't do it.

If you define sustainability as an obligation to leave the world as we found it in detail, I think that's glib but essentially unfeasible. It is, when you think about it, not even desirable. To carry out literally the injunction of UNESCO would mean to make no use of mineral resources; it would mean to do no permanent construction or semi-permanent construction; build no roads; build no dams; build no piers. A mooring would be all right but not a pier. Apart from being essentially an injunction to do something that is not feasible, it asks us to do something that is not, on reflection, desirable. I doubt that I would feel myself better off if I had found the world exactly as the Iroquois left it. It is not clear that one would really want to do that.

To make something reasonable and useful out of the idea of sustainability, I think you have to try a different kind of definition. The best thing

I could think of is to say that it is an obligation to conduct ourselves so that we leave to the future the option or the capacity to be as well off as we are. It is not clear to me that one can be more precise than that. Sustainability is an injunction not to satisfy ourselves by impoverishing our successors. That sounds good too, but I want you to realize how problematic it is—how hard it is to make anything precise or checkable out of that thought. If we try to look far ahead, as presumably we ought to if we are trying to obey the injunction to sustainability, we realize that the tastes, the preferences, of future generations are something that we don't know about. Nor do we know anything very much about the technology that will be available to people 100 years from now. Put yourself in the position of someone in 1880 trying to imagine what life would be like in 1980 and you will see how wrong you would be. I think all we can do in this respect is to imagine people in the future being much like ourselves and attributing to them, imputing to them, whatever technology we can "reasonably" extrapolate—whatever that means. I am trying to emphasize the vagueness but not the meaningless of that concept. It is not meaningless, it is just inevitably vague.

We are entitled to please ourselves, according to this definition, so long as it is not at the expense (in the sense that I stated) of future well-being. You have to take into account, in thinking about sustainability, the resources that we use up and the resources that we leave behind, but also the sort of environment we leave behind including the built environment, including productive capacity (plant and equipment) and including technological knowledge. *To talk about sustainability in that way is not at all empty.* It attracts your attention, first, to what history tells us is an important fact, namely, that goods and services can be substituted for one another. If you don't eat one species of fish, you can eat another species of fish. Resources are, to use a favorite word of economists, fungible in a certain sense. They can take the place of each other. That is extremely important because it suggests that we do not owe to the future any particular thing. There is no specific object that the goal of sustainability, the obligation of sustainability, requires us to leave untouched.

What about nature? What about wilderness or unspoiled nature? I think that we ought, in our policy choices, to embody our desire for unspoiled nature as a component of well-being. But we have to recognize that different amenities really are, to some extent, substitutable for one another, and we should be as inclusive as possible in our calculations. It is perfectly okay, it is perfectly logical and rational, to argue for the preservation of a particular species or the preservation of a particular landscape. But that has to be done on its own, for its own sake, because this landscape is intrinsically what we want or this species is intrinsically important to preserve, not under the heading of sustainability. Sustainability doesn't require that any *particular* species of owl or any *particular* species of fish or any *particular* tract of forest be preserved. Substitutabil-

ity is also important on the production side. We know that one kind of input can be substituted for another in production. There is no reason for our society to feel guilty about using up aluminum as long as we leave behind a capacity to perform the same or analogous functions using other kinds of materials—plastics or other natural or artificial materials. In making policy decisions we can take advantage of the principle of substitutability, remembering that what we are obligated to leave behind is a generalized capacity to create well-being, not any particular thing or any particular natural resource.

If you approach the problem that way in trying to make plans and make policies, it is certain that there will be mistakes. We will impute to the future tastes that they don't have or we will impute to them technological capacities that they won't have or we will fail to impute to them tastes and technological capacities that they do have. The set of possible mistakes is usually pretty symmetric.

That suggests to me the importance of choosing robust policies whenever we can. We should choose policies that will be appropriate over as wide a range of possible circumstances as we can imagine. But it would be wrong for policy to be paralyzed by the notion that one can make mistakes. Liability to error is the law of life. And, as most people around Woods Hole know, you choose policies to avoid potentially catastrophic errors, if you can. You insure wherever you can, but that's it.

The way I have put this, and I meant to do so, emphasizes that sustainability is about distributional equity. It is about who gets what. It is about the sharing of well-being between present people and future people. I have also emphasized the need to keep in mind, in making plans, that we don't know what they will do, what they will like, what they will want. And, to be honest, it is none of our business.

It is often asked whether, at this level, the goal or obligation of sustainability can be left entirely to the market. It seems to me that there is no reason to believe in a doctrinaire way that it can. The future is not adequately represented in the market, at least not the far future. If you remember that our societies live with real interest rates of the order of 5 or 6 percent, you will realize that that means that the dollar a generation from now, thirty years from now, is worth 25 cents today. That kind of discount seems to me to be much sharper than we would seriously propose in our public capacity, as citizens thinking about our obligation to the future. It seems to me to be a stronger discount than most of us would like to make. It is fair to say that those people a few generations hence are not adequately represented in today's market. They don't participate in it, and therefore there is no doctrinaire reason for saying, "Oh well, ordinary supply and demand, ordinary market behavior, will take care of whatever obligation we have to the future."

Now, in principle, government could serve as a trustee, as a representative for future interests. Policy actions, taxes, subsidies, regulations could,

in principle, correct for the excessive present-mindedness of ordinary people like ourselves in our daily business. Of course, we are not sure that government will do a good job. It often seems that the rate at which governments discount the future is rather sharper than that at which the bond market does. So we can't be sure that public policy will do a good job. That is why we talk about it in a democracy. We are trying to think about collective decisions for the future, and discussions like this, not with just me talking, are the way in which policies of that kind ought to be thrashed out.

Just to give you some idea of how uncertain both private and public behavior can be in an issue like this, let me ask you to think about the past, not about the future. You could make a good case that our ancestors, who were considerably poorer than we are, whose standard of living was considerably less than our own, were probably excessively generous in providing for us. They cut down a lot of trees, but they saved a lot and they built a lot of railroad rights-of-way. Both privately and publicly they probably did better by us than a sort of fair-minded judge in thinking about the equity (whether they got their share and we got our share or whether we profited at their expense) would have required. It would have been okay for them to save a little less, to enjoy a little more and given us a little less of a start than our generation has had. I don't think there is any simple generalization that will serve to guide policy about these issues. There is every reason to discuss economic policy and social policy from this point of view, and anything else is likely to be ideology rather than analysis.

Once you take the point of view that I have been urging on you in thinking about sustainability as a matter of distributional equity between the present and the future, you can see that it becomes a problem about saving and investment. It becomes a problem about the choice between current consumption and providing for the future.

There is a sort of dual connection—a connection that need not be intrinsic but is there—between environmental issues and sustainability issues. The environment needs protection by public policy because each of us knows that by burdening the environment, by damaging it, we can profit and have some of the cost, perhaps most of the cost, borne by others. Sustainability is a problem precisely because each of us knows or realizes that we can profit at the expense of the future rather than at the expense of our contemporaries and the environment. We free-ride on each other and we free-ride on the future.

Environmental policy is important for both reasons. One of the ways we free-ride on the future is by burdening the environment. And so current environmental protection—this is what I meant by a dual connection—will almost certainly contribute quite a lot to sustainability. Although, I want to warn you, not automatically. Current environmental protection contributes to sustainability if it comes at the expense of current consump-

tion. Not if it comes at the expense of investment, of additions to future capacity. So, there are no absolutes. There is nothing precise about this notion but there are perhaps approximate guides to public policy that come out of this way of reasoning about the idea of sustainability. A correct principle, a correct general guide is that when we use up something—and by we I mean our society, our country, our civilization, however broadly you want to think—when we use up something that is irreplaceable, whether it is minerals or a fish species, or an environmental amenity, then we should be thinking about providing a substitute of equal value, and the vagueness comes in the notion of value. The something that we provide in exchange could be knowledge, could be technology. It needn't even be a physical object.

Let me give you an excellent example from the recent past of a case of good thought along these lines and also a case of bad thought along these lines. Commercially usable volumes of oil were discovered in the North Sea some years ago. The two main beneficiaries of North Sea oil were the United Kingdom and Norway. It is only right to say that the United Kingdom dissipated North Sea oil, wasted it, used it up in consumption and on employment. If I meet Mrs. Thatcher in heaven, since that is where I intend to go, the biggest thing I will tax her with is that she blew North Sea oil. Here was an asset that by happenstance the U.K. acquired. If the sort of general approach to sustainability that I have been suggesting to you had been taken by the Thatcher government, someone would have said, "It's okay we are going to use up the oil, that's what it is for, but we will make sure that we provide something else in exchange, that we guide those resources, at least in large part, into investment in capacity in the future." That did not happen. As I said, if you ask where (and by the way the curve of production from the North Sea fields is already on the way down; that asset is on its way to exhaustion) it went, it went into maintaining consumption in the United Kingdom and, at the same time, into unemployment.

Norway, on the other hand, went about it in the typical sober way you expect of good Scandinavians. The Norwegians said, here is a wasting asset. Here is an asset that we are going to use up. Scandinavians are also slightly masochistic, as you know. They said the one thing we must avoid is blowing this; the one thing we must avoid is a binge. They tried very hard to convert a large fraction of the revenues, of the rentals, of the royalties from North Sea oil into investment. I confess I don't know how well they succeeded but I am willing to bet that they did a better job of it than the United Kingdom.

This brings me to the one piece of technical economics that I want to mention. There is a neat analytical result in economics (mainly done by John Hartwick of Queen's University in Canada) which studies an economy that takes what we call the rentals, the pure return to a non-renewable

resource, and invests those rentals.<sup>1</sup> That is, it uses up a natural asset like the North Sea oil field, but makes a point of investing whatever revenues intrinsically inhere to the oil itself. That policy can be shown to have neat sustainability properties. In a simple sort of economy, it will guarantee a perpetually constant capacity to consume. By the way, it is a very simple rule, and it is really true only for very simple economies; but it has the advantage, first of all, of sounding right, of sounding like justice, and secondly, of being practical. It is a calculation that could be made. It is a calculation that we don't make and I am going to suggest in a minute that we should be making it. You might want to do better. You might feel so good about your great-grandchildren that you would like to do better than invest the rents on the non-renewable resources that you use up. But in any case, it is, at a minimum, a policy that one could pursue for the sake of sustainability. I want to remind you again that most environmental protection can be regarded as an act of investment. If we were to think that our obligation to the future is in principle discharged by seeing that the return to non-renewable resources is funnelled into capital formation, any kind of capital formation—plant and equipment, research and development, physical oceanography, economics or environmental investment—we could have some feeling that we were about on the right track.

Now I want to mention what strikes me as sort of a paradox—as a difficulty with a concept of sustainability. I said, I kind of insisted, that you should think about it as a matter of equity, as a matter of distributional equity, as a matter of choice of how productive capacity should be shared between us and them, them being the future. Once you think about it that way you are almost forced logically to think about equity not between periods of time but equity right now. There is something inconsistent about people who profess to be terribly concerned about the welfare of future generations but do not seem to be terribly concerned about the welfare of poor people today. You will see in a way why this comes to be a paradox. The only reason for thinking that sustainability is a problem is that you think that some people are likely to be shortchanged, namely, in the future. Then I think you really are obligated to ask, "Well, is anybody being shortchanged right now?"

The paradox arises because if you are concerned about people who are currently poor, it will turn out that your concern for them will translate into an increase in current consumption, not into an increase in investment. The logic of sustainability says, "You ought to be thinking about poor people today, and thinking about poor people today will be disadvantageous from the point of view of sustainability." Intellectually, there is no difficulty in resolving that paradox, but practically there is every

<sup>1</sup>John M. Hartwick, "Substitution among exhaustible resources and intergenerational equity," *Review of Economic Studies* 45(2): 347-543 (June 1978).

difficulty in the world in resolving that paradox. And I don't have the vaguest notion of how it can be done in practice.

The most dramatic way in which I can remind you of the nature of that paradox is to think about what it will mean for, say, CO<sub>2</sub> discharge when the Chinese start to burn their coal in a very large way; and, then, while you are interested in moral obligation, I think you should invent for yourself how you are going to explain to the Chinese that they shouldn't burn the coal, even living at their standard of living they shouldn't burn the coal, because the CO<sub>2</sub> might conceivably damage somebody in 50 or 100 years.

Actually the record of the U.S. is not very good on either the inter-generational equity or the intra-generational equity front. We tolerate, for a rich society, quite a lot of poverty, and at the same time we don't save or invest a lot. I've just spent some time in West Germany, and there is considerably less apparent poverty in the former Federal Republic than there is here; and at the same time they are investing a larger fraction of their GNP than we are by a large margin.

It would not be very hard for us to do better. One thing we might do, for starters, is to make a comprehensive accounting of rents on non-renewable resources. It is something that we do not do. There is nothing in the national accounts of the U.S. which will tell you what fraction of the national income is the return to the using up of non-renewable resources. If we were to make that accounting, then we would have a better idea than we have now as to whether we are at least meeting that minimal obligation to channel those rents into saving and investment. And I also suggested that careful attention to current environmental protection is another way that is very likely to slip in some advantage in the way of sustainability, provided it is at the expense of current consumption and not at the expense of other forms of investment.

I have left out of this talk, as some of you may have noticed until now, any mention of population growth; and I did that on purpose, although it might be the natural first order concern if you are thinking about sustainability issues. Control of population growth would probably be the best available policy on behalf of sustainability. You know that, I know that, and I have no particular competence to discuss it any further; so I won't, except to remind you that rapid population growth is fundamentally a Third World phenomenon, not a developed country phenomenon. So once again, you are up against the paradox that people in poor countries have children as insurance policies for their own old age. It is very hard to preach to them not to do that. On the other hand, if they continue to do that, then you have probably the largest, single danger to sustainability of the world economy.

All that remains for me is to summarize. What I have been trying to say goes roughly as follows. Sustainability as a moral obligation is a general obligation not a specific one. It is not an obligation to preserve this or

preserve that. It is an obligation, if you want to make sense out of it, to preserve the capacity to be well off, to be as well off as we. That does not preclude preserving specific resources, if they have an independent value and no good substitutes. But we shouldn't kid ourselves, that is part of the value of specific resources. It is not a consequence of any interest in sustainability. Secondly, an interest in sustainability speaks for investment generally. I mentioned that directing the rents on non-renewable resources into investment is a good rule of thumb, a reasonable and dependable starting point. But what sustainability speaks for is investment, investment of any kind. In particular, environmental investment seems to me to correlate well with concerns about sustainability and so, of course, does reliance on renewable resources as a substitute for non-renewable ones. Third, there is something faintly phony about deep concern for the future combined with callousness about the state of the world today. The catch is that today's poor want consumption not investment. So the conflict is pretty deep and there is unlikely to be any easy way to resolve it. Fourth, research is a good thing. Knowledge on the whole is an environmentally neutral asset that we can contribute to the future. I said that in thinking about sustainability you want to be as inclusive as you can. Investment in the broader sense and investment in knowledge, especially technological and scientific knowledge, is as environmentally clean an asset as we know. And the last thing I want to say is, don't forget that sustainability is a vague concept. It is intrinsically inexact. It is not something that can be measured out in coffee spoons. It is not something that you could be numerically accurate about. It is, at best, a general guide to policies that have to do with investment, conservation and resource use. And we shouldn't pretend that it is anything other than that.

Thank you very much. --

## REFERENCES

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- World Commission on Environment and Development, *Our Common Future* (The Brundtland Report). Oxford: Oxford University Press, 1987.
  - World Conservation Union, *Caring for the Earth*. Gland, Switzerland, 1991; see especially p. 10.
  - World Resources Institute, *World Resources 1992-93: Toward Sustainable Development*. New York: Oxford University Press, 1992. See especially Ch. 1.