Mitigating Strategies for CO₂ Problems

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ABSTRACT

Vast uncertainties surround our ability to predict the social effects of increased carbon dioxide concentrations in the atmosphere during the next century; fossil fuel combustion rates will change, predicting global climate changes is difficult, and predicting the resulting social reactions to these changes is essentially impossible. Furthermore, time must elapse before there is convincing proof of the expected amount of climate change, before people perceive the magnitude of the problem and accept its existence, before we can act to abate emissions, and before the capital can be put into place. In addition, it will be extraordinarily difficult to convince all nations to abate carbon dioxide, especially since some will gain from the climate changes. Thus, we must focus on adaptation to future climate change, rather than attempting to abate carbon dioxide emissions in order to prevent change.

Unfortunately, the effects of carbon dioxide are likely to be insidious and difficult to connect to climate change. Myriad effects, both good and bad are unlikely to be recognized as caused by carbon dioxide.

Conscious adaptation policies have the government or other social institutions act directly to mandate change in behavior through laws, fines, or subsidies. Unfortunately, such actions cannot be tailored to achieve precise objectives; they are blunt tools that should be used only for important goals and then sparingly. Unconscious adaptation takes place through behavioral changes induced by the market place or social institutions. These mechanisms can be swift and powerful, but are

difficult to manipulate.

Actions such as monitoring climate change and taking care to inform important groups of the current state of knowledge on carbon dioxide induced climate changes can help to speed adaptation along with contingency planning and development of nonfossil fuel technologies can speed adaptation. More important are plans which would set unconscious adaptation into motion, such as plans to disseminate information on the problem and behavior which will help individuals or firms.

Of greatest importance is having a society that can quickly perceive and adapt to the new regime. This means a strong economy, high scientific and engineering capabilities, a well educated population, and a more flexible, resilient capital stock. These social and economic characteristics are desirable for a host of reasons unrelated to carbon dioxide. Carbon dioxide can serve as a catalyst in promoting policies that are justified for a host of reasons.

I. Introduction

Atmospheric concentrations of carbon dioxide have been increasing for more than a century due to human activities such as the clearing of forests and combustion of fossil fuels. Since the latter is forecast to accelerate over the foreseeable future, atmospheric concentrations will increase over future decades. The increased carbon dioxide is predicted to warm the Earth's climate, particularly at the poles and to change precipitation and other aspects of climate, as well as change ocean

movements. However, the atmospheric changes probably will not be measureable until at least the turn of the century and the effects will not be of substantial magnitude until well into the 21st Century.¹

Four levels of uncertainty complicate efforts to examine the implications of carbon dioxide emissions. The first is the amount of fossil fuel that will be burned each year; this depends on world population and economic activity, and on the supply of energy sources and technologies for utilizing energy. The second is the physical effects on the cryosphere and oceans for any concentration of atmospheric carbon dioxide and the rate at which the atmosphere will slough off carbon dioxide to the ocean or plants. The third is the direct effect of the changes in climate and ocean dynamics on biota. The fourth is the extent to which human behavior and institutions can and will mitigate the adverse effects of the physical and biological changes or even utilize these changes to accomplish individual and social goals better. This essay is focused on policies that governments might adopt in order to shield society from adverse carbon dioxide induced effects and to enable society to take advantage of beneficial effects.

Policies designed to lessen carbon dioxide emissions are unattractive. Fossil fuels are the cheapest source of energy at present; proscribing them would be difficult and expensive. More importantly, the social effects will be highly uncertain until at least half a century in

1. R. Madden and V. Ramanathan, "Detecting Climate Changed Due to Increasing Carbon Dioxide," Science, 209 #4458, August 15, 1980.

the future. It would be extremely difficult to convince any nation to bear the higher costs associated with curtailing fossil fuel use, particularly since we can neither estimate the magnitude of change with assurance nor be certain that the physical changes will be harmful, or even predominantly detrimental to humans. Even more difficult would be convincing all nations to eschew fossil fuels. These difficulties are so immense that it is impractical to plan that much will be done to abate carbon dioxide emissions before the middle of the next century, and only then if the effects are predominately adverse, important, and adaptation is unable to mitigate the costs.

The lags associated with mitigation are important. First there is a recognition lag associated with obtaining convincing proof that carbon dioxide will cause large, adverse effects. As early as 2000, we could receive confirmation that the global climate models (GCM) are correctly predicting the gross climate effects. However, there would remain considerable uncertainty that effects which are of second or third order of importance under the current climate regime would not become of first order in the new regime with elevated carbon dioxide levels. If so, the GCM might correctly forecast the small climate changes associated with small increases in carbon dioxide concentration, but be incorrect for the climate changes associated with major increases in carbon dioxide concentrations. Even then, changes could turn out to produce beneficial rather than adverse outcomes.

A second lag is that associated with general recognition of the problem and deciding on a solution. The perceived seriousness of the problem should vary with location, occupation, income, and perceived

alternatives. For example, seven years after the abrupt change in petroleum supply resulting from the Arab oil embargo and quadrupling of oil price, there is little agreement within the U.S.A. or world community about what policies to pursue. Getting agreement on the carbon dioxide problem and its solution could take decades.

One factor making international agreement difficult is the international public good nature of carbon dioxide.² Atmospheric concentration of CO₂ is a public good (or bad) in that no small nation can have noticeable effect on climate change by its individual program to abate carbon dioxide emissions. Furthermore, there is every incentive to cheat since one nation's emission would not have much effect on climate if every other nation eschewed fossil fuels. Yet, clearly the total emission is the sum of the emissions of each nation. Finally, some nations stand to gain from climate change and would encourage fossil fuel burning.

The third lag is that required to switch fuel sources once agreement has been reached on policies. Other fuels must be extracted and high investments and retraining of labor are required. Several decades would be required to change fuel sources.

These lags are likely to be so long that it would be the latter part of the next century before carbon dioxide emissions were substantially curtailed. Absent some other reason for giving up fossil fuels, we can be virtually certain that substantial climate change would

2. Mancur Olson, "A Conceptual Framework for Research About the Likelihood of a "Greenhouse Effect," working paper, University of Maryland, July 1980.

have occurred and would persist. Thus, the emphasis must be on adaptation to the new climate regime, to turning physical changes into beneficial ones for human activities.

II. Identifying Carbon Dioxide Effects

The GCM predict changes in temperature and precipitation resulting from increased concentrations of carbon dioxide. However, there is great variation from day to day, region to region, or year to year in climate. It will be difficult to identify the effect of carbon dioxide in the midst of natural fluctuations.

The effect on human activity due to climate change is likely to be small compared to that stemming from other events. For the next century, wars, economic competition, usual climate fluctuations, and technological change probably will be more important than the long term climate changes due to carbon dioxide. Carbon dioxide is likely to seem unimportant beside the myriad current, short lived opportunities and problems.

Nor are the consequences of climate change easily attributed to the correct cause. Climate change might cause life style changes, such as forcing a group of farmers to move into cities, which in turn lead to increases in crime or civil disorder. The perceived problem would be the crime and violence and it would be far from obvious that carbon dioxide was the culprit. Similarly, unemployment, regional strife, or even world war might result from carbon dioxide, but it is unlikely that there would be general recognition of the cause. Alternatively, in regions where growing conditions improved, the change would probably be ascribed to some combination of astute planning and good luck.

While physical changes, such as temperature and precipitation can be measured, it is more difficult to measure the direct human reactions to climate change, such as new cropping patterns. Virtually impossible to measure would be the tertiary effects, good and bad, that flow from cascading social adjustment. If social institutions are functioning well, the effects will be beneficial on net, but will be so diverse that they could not be linked to carbon dioxide. If institutions are not functioning well, effects such as urban crowding, crime and riots are not likely to be perceived as due to carbon dioxide. Thus, it seems unlikely that society will be provided with convincing proof that action must be taken to reduce carbon dioxide emissions because the consequences are intolerable -- at least not until climate changes are very large.

III. Methods for Adaptation

For the reasons cited above, the emphasis must be on adaptation, not prevention. In an effort to understand adaptation, I discuss the two principal methods.

Explicit or Conscious Adaptation

The usual conception of adaptation focuses on actions taken by some level of government or some conscious change in behavior in response to a perception of the need for change. These explicit or conscious adaptations result from information about change and about changes in behavior that would mitigate damage or be beneficial. For explicit adaptation to occur, some authoritative source must present information in an understandable form, convince the decision makers that change is desirable and feasible, and facilitate change.

One route to explicit adaptation would be convincing government decision makers at a local, state, national or international level about the desirability and feasibility of change, thereby securing legislation to compell changes in the behavior of individuals and institutions. Another mode would be dissemination of information, as through the media. For example, current government research is attempting to estimate the physical and social effects of carbon dioxide so that government officials and the public can acquire the information needed to make informed choices.

The hallmark of conscious adaptation is legal compulsion or explicit recognition of a problem and the possible solutions; in both cases behavior change results from widespread dissemination of information. The presentations must be such that the problem is readily understood; dissemination must ensure that information gets to decision makers and appears authoritative. However, as the warning on cigarette packs or laws against smoking marihuana indicate, inducing changes in behavior is difficult.

The decisions to be influenced by climate change include those concerning investments, education and training, migration and location generally, jobs, and the production and purchase of goods and services. The facts that are pertinent, people to be reached, and points of leverage vary with each target.

Explicit government intervention to change behavior might take the form of laws, taxes, subsidies, licensing and control of conditions of operation, and moral suasion. Laws define property rights and tolerable behavior. Violations bring incarceration, fines or other criminal and

civil penalties. In the extreme, execution or lifelong incarceration can prevent proscribed behavior. Laws are a direct way of changing behavior, but often are unsuccessful. Laws work best when there is a clearly identified action, such as murder, which is abhorred. They do not work in attempting to change behavior to correspond to the moral beliefs of a minority, e.g., prohibition. Unfortunately mitigating the problems caused by carbon dioxide is likely to require subtle changes in behavior that could not be induced by laws.

Laws can also influence behavior by zoning, declaring areas off limits to various activities (e.g., wilderness areas), or generally changing property rights and the conditions under which business can operate. For example, a forecast rise in sea level due to carbon dioxide induced warming might cause rezoning that prevented new buildings from being constructed in areas which would be flooded.

Taxes and subsidies can provide various degrees of incentive to change behavior. For example, the subsidy to gasohol resulted in rapid, large scale increases in production. Taxes on gasoline which caused vast differences in price resulted in large differences in fuel economy between automobiles designed for use in the U.S.A. and those designed for use in most European nations in the 1960s. The difficulty is designing taxes and subsidies that will accomplish the intended goal. Professional advisers ensure that taxes and subsidies are used for many purposes other than those intended. For example, Nordhaus³ has proposed a tax of \$10 per ton

3. William Nordhaus, "Thinking About Carbon Dioxide: Theoretical and Empirical Aspects of Optimal Control Strategies," Yale University working paper, July 1980.

of carbon released into the atmosphere. The narrow focus of this proposal might be compared to others such as subsidies for nuclear power or prohibiting synfuels.

Licensing of workers and businesses and regulation of the conditions of operation are used by state and local government to accomplish such purposes as assuring minimum quality standards and regulating location. Implementation and enforcement of these rules is difficult and limits their applicability. More importantly, there is the temptation to use taxes, subsidies, licences, etc., to reward special groups or accomplish unrelated, often socially undesirable goals, such as raising the income of a group such as barbers at the expense of the public. Economists have learned painfully that legislating any type of tax subsidy or regulation is predominantly a political process whose outcome will have little semblance of economic efficiency. While these tools are available in theory, in practice they are used to accomplish other ends and are largely ineffective.

The effect of moral suasion by the government should not be underestimated. Where it is not against the perceived self-interest of individuals, moral suasion can lead to important changes in behavior, as evidenced by energy or water conservation during crises. Even where the individual is required to make a sacrifice, most will do so if there is a perceived threat to society and a perception that all individuals will share the burden, e. g. , serving in the armed forces during World War II. If Americans could be convinced that carbon dioxide is a serious problem, they would probably respond to appeals to conserve energy.

Implicit or Unconscious Adaptation

Conscious adaptation is a blunt instrument, subject to all of the difficulties of enacting legislation or other formal rules. It is a direct way of compelling changes in behavior and is thus appealing. But it is subject to major defects, such as speed of enacting change. More important than explicit adaptation is implicit or automatic adjustment. For example, adjustment to changes in consumer preferences for goods and services is done automatically via prices and profits through the market place. Neither the government nor any national organization need recognize the change and prescribe action. Indeed, most shifts in tastes are accommodated without explicit recognition. If fossil fuels became more expensive, due for example to a tax on carbon emitted into the atmosphere, business and consumers would be led to an automatic shift toward other energy sources.

This is not to imply that national recognition of a change would not take place or would not serve to expedite adjustment and lower social costs. Current government activity to estimate the effects of carbon dioxide could inform business and consumers, thereby helping them to adjust. However, data collection and analysis, recognition of changes, and dissemination of the information is a profitable non-governmental activity since it recognizes profit opportunities and reduces loss. For example, a number of large companies now specialize in collection of data, e. g. , survey firms, or making economic forecasts. While some information collection and dissemination is a public good with a role for government, the vast proportion takes place privately.

Early recognition of changes in consumer tastes, climate conditions, or production opportunities have vast implications for profits. Being first to recognize and adapt has immensely different implications than being slow to recognize the change. For individuals and organizations that have no capacity to gather and analyze data on carbon dioxide induced climate change, the market provides unmistakable signals in the form of crop failure, unemployment, bankruptcy or more subtly in lower wages and profits for some businesses contrasted with profit increases and higher wages for others. Firms making windfall profits grow and are imitated. Thus business and workers are led, as if by an "invisible hand" to adjust to the changing market.

The social structure also promotes adaptive behavior. For example, age at marriage and number of children are influenced significantly by social norms. Similarly, job choice, geographical location, time in the labor force, and food preferences are affected by social institutions. Social pressures speeded the diffusion of television in the 1940s and could speed the demise of large cars in the 1980s; they affect family size, total population, total economic activity, and consumption patterns, thus indirectly affecting CO₂ emission rates and adaptation to climate change.

Unconscious adaptation translates subtle cues into individual and social change. It is purposive in reducing dissonance between the individual and his environment, either by exploiting new opportunities or cutting losses. Whether it is helpful for a community, nation, or the world depends on the aggregation of individual actions. The institutional and technological structure of society determine whether individuals

acting in their self interest speed or impede needed social adjustment. The economic model of perfect competition is one institutional framework where individual nations are perfectly consonant with social objectives.

While there is no doubt of the power of social institutions in influencing behavior, there is vast uncertainty associated with how climate changes would effect social institutions thereby affecting behavior. We know almost nothing about how governments could manipulate social institutions so as to facilitate adaptive behavior toward climate change. Presumably government could influence the media and opinion leaders as a means of influencing social institutions generally.

There should be planned dissemination of results as the carbon dioxide research proceeds, particularly careful education of reporters, environmental, and other interest groups. However, care must be taken not to waste good will and credibility by dissemination of material that does not have new results or of material so speculative as to have a large chance of being wrong.

IV. Enhancing the Capacity to Adapt

Carbon dioxide induced climate and ocean changes may require changes in location of businesses, residences and such social overhead capital as streets and sewers. Large amounts of plant and equipment must be replaced, and workers may have to find new jobs, often in new locations and involving new skills. Firms may have to redesign their products and manufacturing processes. Furthermore, these changes will be in addition to changes due to shifts in taste, technological change, changing availabilities of raw materials, changing patterns of international trade

and relations, and vast "normal" variation in climate. The ability to adapt to the carbon dioxide induced changes will be determined by the ability to adapt to the other changes.

Will the automatic mechanisms send the proper signals? Will government and other decision makers perceive the problem and implement policies that will expedite adaptation? If people perceive the need to change their behavior, will they have the resources and knowledge to change? Will the social and economic institutions be able to keep pace with climate and social change?

Whether society will have the required resources to adapt will be measured by several indices. The first is gross national product (or income) per capita. This is a measure of aggregate economic activity and is a surrogate for the economic resources to build new facilities or move people.⁴

The second is the gross rate of investment or ratio of investment to GNP. A high ratio means that the economy is putting many new facilities into place and turning over its capital stock rapidly. Since new plant and equipment can be designed for the new situations and be built in the right places, rapid turnover means that most of the capital stock can be tailored to the new regime. For example, consider an economy in which capital lasts 50 years and so only 2 percent of capital is

4. The precise variable is "free" economic resources per capita. A poor society, such as nomads might be able to adapt more easily than a rich society unwilling or unable to direct resources to implement needed changes.

replaced each year. Climate change will make much of the capital obsolete, but the obsolete capital will remain for a long time. In contrast, consider an economy that turns over its capital stock every decade. As changes are perceived, they can be incorporated into new capital so that little plant and equipment will ever be obsolete.

A third measure of the capacity of the economy to adapt will be the general education level of workers. Educated workers find it easier to acquire the new skills required for new jobs.⁵ A skilled labor force can redesign products and facilities to respond to new conditions.

For the other three characteristics facilitating adaptation, there are no simple measures. The fourth characteristic will be the flexibility and diversity of the capital stock. Some plant and equipment is so highly specialized that minor changes in raw materials, product design or fuels are impossible to accomodate. For example, some oil refineries were built to process only a narrow type of crude oil and produce a fixed set of outputs. Another example is an electricity generation unit that can be designed to burn natural gas, oil, coal, any two, or all three fuels. The greater the flexibility, the less need to replace the capital and the easier will be adjustment. Diversity of the capital stock gives the economy the resiliency to avoid disaster in the face of changing conditions such as climate. An analogy is planting a number of varieties of some grain, rather than depending on a monoculture. The monoculture

5. Edward F. Denison, Accounting for United States Economic Growth, 1929-1969, Washington: Brookings Institution, 1974.

can give greater yield under a narrow range of conditions but can lead to crop failure if conditions change. Similarly, building flexible, diverse capital (like the generator that can use three fuels) increases cost or lowers output (like planting many varieties of a grain), but offers insurance against changing conditions.

A fifth characteristic is the amount of basic scientific knowledge and the number of technological alternatives currently available or that can be developed quickly. The greater is scientific knowledge, the more opportunity to design technology appropriate to the new conditions. The greater the variety of currently available technology, the greater the chance that some "on the shelf" technology will fit the new conditions. However, both increasing scientific knowledge and perfecting more technologies is costly.

A sixth characteristic is the capacity of individuals to interpret the signals of changing conditions correctly and to adapt to them quickly. A better educated population and good planning organizations in social institutions will help. The ability and willingness of planners to recognize the signals and interpret them for the population and social institutions that lack this ability is important. This includes collection of the right data so as to recognize change early and to interpret the conditions to follow. The federal government has an obligation and important role in collecting and analyzing data and disseminating the interpretations.

V. Conclusions

Society can take steps to enhance each of these characteristics of our ability to adapt more easily to carbon dioxide induced changes. Given the rapidity of social and technological change in the 20th century, facilitating adjustment is important. With the exception of data collection and analysis focused on climate, enhancing each of these functions will be to the general benefit of society, but will not be unique to carbon dioxide induced problems. Carbon dioxide issues can provide a rationale, but more probably will be a catalyst, for pushing society to enhance its ability to adapt to and exploit change. Carbon dioxide is but one of many factors which will have an enormous impact on the economy and social institutions of the United States in the 21st century. If carbon dioxide induced changes were as large as now appears possible, and if they were the only major changes, then it would be worth while to invest in enhancing education and capital formation so that we could minimize the effects of adverse changes and take advantage of beneficial changes. Since carbon dioxide induced changes are likely to be only one, possibly small, source of change, there is all the more reason to devote resources to making our economic and social institutions more flexible and adaptable.