



The Environmental Prisoners' Dilemma

Or

We're All in This Together: Can I Trust You to Figure it Out?

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1. Introduction

The problems of global warming and long-term climate change are real. The solution is both expensive and technologically complex; it is also both economically and technologically feasible. The greatest obstacles to resolving the threat of long-term climate change remain social and political, rather than financial or technical. These problems have, in the past, proven to be intractable because the gains from environmental exploitation are immediate and certain and they accrue to the exploiters, while the benefits of environmental amelioration are in the more distant future, are less certain, and are diffuse, that is, shared with the entire population rather than being retained by those who make the effort to reduce their environmental impacts. Adding to the complexity is the need to coordinate activities among numerous companies, numerous national governments, numerous trading blocs, and numerous populations.

The following assumptions are essential to our argument; we do not defend them here, but instead refer the reader to any of a number of sources:

We have not attempted to review and evaluate the scientific evidence; rather, we make the following scientific assumptions:

- Global warming and long-term climate change are real.
- There have always been fluctuations in the earth's climate, principally driven by changes in the sun's emissions and by volcanic action on earth.
- The current changes are greater than those predicted by computer simulation models based on the sun and volcanism, and are believed to be caused by the increase in greenhouse gases, notably CO₂, that have been released in great quantities since the Industrial Revolution. These changes are man-made and will continue and indeed will worsen as the amounts of CO₂ emitted by human activity continue to increase.

- Ultimately, climate change will be a serious economic problem, causing loss of coastal areas as a result of rising sea levels, floods and draughts, and famine.
- The cost of dealing with long-term climate change is high, but almost certainly far less than the economic cost of failing to act.¹

In addition, we make the following behavioral assumptions:

- Individuals are generally not good at making decisions that require that they trade off uncertain future benefits against certain and immediate costs.
- It is even more difficult to coordinate the decisions of large groups when asking them to accept immediate and certain costs in order to gain future and uncertain benefits.
- Governments made up of elected officials find it difficult to coordinate long-term policies that produce future and uncertain benefits, but impose costs that might decrease their chances of reelection.
- No company is going to undertake large capital investments unilaterally to reduce the environmental damage it causes if its competitors do not; the expense of doing so will damage or destroy the company's competitive position.
- At present neither the United States nor China is going to take action unilaterally to reduce the environmental damage it causes if the other does not. The expense of doing so will damage the competitive position of its companies' goods and will add to the costs of goods and services produced for domestic consumption. This will reduce economic growth and will reduce the quality of life for the country's citizens.
- The populations of the EU and the US are growing more concerned about and more aware of the problems associated with long-term climate change, but their elected officials are more conservative than their citizens and less well informed than their industrial leaders.

We do not focus here on the engineering strategies needed to achieve levels of CO₂ emissions that will stabilize our environment, but rather on the international negotiations strategies that will be required.

2. The Prisoners' Dilemma

The story of the Prisoners' Dilemma is a highly stylized game that illustrates that sometimes common sense works better than theory, and that without common sense sometimes even the simplest dilemma has no formal solution. We'll start with the hypothetical tale of two petty criminals, and then see how this applies to the analysis of long-term climate change and global warming.

In its purest form, the game works something like this: Two hoodlums are picked up by the police for a crime that they committed, that the police know they committed, and that the police

¹ For a brief and compelling review of the costs and dangers of global warming and long-term climate change, see the 30 October 2006 Review of the Economics of Climate Change, by Sir Nicholas Stern, Head of the (UK) Government Service and former Chief Economist of the World Bank. The implications, in terms both of expected economic losses and of human suffering, are described in compelling detail in the report. (http://news.bbc.co.uk/2/shared/bsp/hi/pdfs/30_10_06_exec_sum.pdf).

cannot prove that they committed. Everyone knows what everyone else knows; for example, the hoodlums know that the police know that they know ... etc.

The police *really* want to convict these guys, and know that they can frame them for something else if they can't convict them for this crime. If nothing changes, both prisoners will serve short jail sentences, maybe 1 year. But the police *really* want to get *someone* for that big crime that they know the two guys committed. The prisoners are separated and neither can speak to the other to coordinate a strategy. Each is told that there is an offer on the table. If one of the prisoners cooperates, confesses, and turns States Evidence against the other, he will serve only six months while his betrayed partner will serve 10 years. Obviously, there is a big reward for confessing. However, if they *both* confess then they will both serve 5 years instead of the 1 year they would have served if they both remained silent; just as obviously, there is a big penalty for confessing unnecessarily. Since neither prisoner can speak to the other it's necessary for them to develop a strategy independently, in ignorance of their partner's actions.

So ... what should you do if the police offer you the opportunity to cop a plea? Let's see how the four possible outcomes compare. If your partner confesses, you should confess to protect yourself (the lower red arrow in figure 1 moves you to a better outcome) and if your partner does not confess you should still confess to shorten your prison stay (the upper red arrow in figure 1 likewise moves you to a better outcome). In either confessing shortens your prison term by half. Of course the analysis is the same for the other hoodlum (the two green arrows in figure 1 both move him to a better outcome). You both follow the arrows, and you both end up both confessing, in order to cut your jail time in half, and you spend five years in jail (that is, the arrows lead you to the lower right box). This is not the worst it could be for either of you, but it's much worse than it needs to be, with a short stay for each of you (upper left box). And this nonsensical outcome appears, to some analysts, to be not only plausible but rational and inevitable.

		Your Plea	
		Not Guilty	Guilty
Your Partner's Plea	Not Guilty	You: 1 year Partner: 1 year	You: 6 Months Partner: 10 Years
	Guilty	You: 10 Years Partner: 6 months	You: 5 Years Partner: 5 Years

Figure 1.—A classic representation of the Prisoners' Dilemma

3. The Planetary Climate Change Prisoners' Dilemma

What does this simple game tell us about prospects for negotiating and honoring international treaties to deal with long-term climate change? Imagine for simplicity that we are negotiating only with China. We should both clean up our production and consumption and we should both cut back on emissions that contribute to global warming. We both know that long-term climate change will be devastating, with droughts and famines, food wars and wars over water, long before we all finally perish. But we know that we cannot cut emissions sufficiently acting alone,

and we know the Chinese can't either. Of course, if we both cut emissions everyone on Earth will be better off. But if only we clean up, the capital expense will make our manufactured goods more costly, we will be less competitive in the international marketplace, and our goods will be at an enormous disadvantage. Of course, if only the Chinese clean up they face the same problem. This is just the Prisoners' Dilemma again, this time applied to global warming².

This simplistic analysis has formed the basis for the Bush administration's environmental policy and is the basis for their refusing to accept the Kyoto accords. Perhaps it is the basis for the actions of the Chinese Politburo as well. Looking at figure 1 we believe we know what the Chinese will do, after thinking through the Prisoners' Dilemma. They won't do a thing to clean up their corporate polluters, nor will they do anything that reduces consumers' ability to enjoy the benefits of their surging economy, such as increased meat consumption or more private vehicles. If we clean up our environmental act and the Chinese don't we all die anyway and their economy will outperform ours while we live. If we don't clean up our act, we still all die, but at least we have a stronger economy until then. What could be more clear? Refuse to sign environmental pacts, argue that global warming is opinion not science, and play the game "optimally." Once again the red and green arrows lead us to the lower right corner.

4. More Realistic Rules for The Planetary Climate Change Prisoners' Dilemma

But this *can't* be right! Ever since we were kids we have been told to "play nice," and any six year old in daycare can do better than the theoretical predictions that lead us to global meltdown. The groundbreaking analysis that showed how to handle the Prisoners' Dilemma was presented by Anatole Rapoport over 30 years ago. Let's rethink this several ways. First, let's change one of the rules. Let the two prisoners talk before making up their decisions. That changes the game really fast. Let's both make sound long term-decisions. We just agree to end up in the upper left hand corner.

Or we can change a second rule. How about saying you'll have to play the game over and over, not for jail terms but for money, as shown in figure 2. Not surprisingly, even without a chance to talk, most guys figure out that they can make \$5 each time they play, over and over again, rather than losing \$10. Not only is this plausible, experiments have verified that this is the best strategy and that teams usually do figure this out. We very quickly learn to ignore the red and green arrows and end up in the upper left box instead.

² For simplicity we are assuming that the nations of the EU, along with Japan and many other signatories to the Kyoto Accords, actually do honor those accords, with the US and China therefore assuming the role of principal polluters. This allows us to deal with the problem of reducing pollution as if it were simply a matter of coordinating the actions of these two nations. If the compliance with the emissions targets set in the second Kyoto round is no better than compliance with the targets set in the first round, then the prisoners' dilemma is not sufficiently powerful. We would then need to describe the problem using the more robust model of Garret Hardin's Tragedy of the Commons, among the most influential papers published in the early history of the environmental movement (Hardin, G. "The Tragedy of the Commons" *Science*, (December 1968), Vol. 162, No. 3859, pp. 1243 – 1248.)

		Your Plea	
		Not Guilty	Guilty
Your Partner's Plea	Not Guilty	You: \$5 Partner: \$5	You: \$10 Partner: -\$10
	Guilty	You: -\$10 Partner: \$10	You: -\$5 Partner: -\$5

Figure 2.—A representation of the Prisoners' Dilemma with cash payoffs rather than prison sentences.

How about a third rule change? Suppose we change the payoff matrix once again, so that the “let’s both cheat” outcome really is the worst ... no matter what your partner does, pleading guilty is a bad idea. This is the environmental pollution game, where you and your partner have the choice of going green or continuing with business as usual. This is shown in figure 3. Over the long term, after the costs of investment in pollution abatement have been made, the payoff for both sides going green is business as usual; we represent this “no change” outcome as a payoff with incremental value \$0. The alternatives — global meltdown, loss of coastal areas to rising sea levels, draught, famine, and war we signify as a reduction in welfare for both players as a *really big* negative number. Nobody wants this outcome. The red and the green arrows are now more complex; while investing in a green environmental policy doesn’t help if your partner does not do so, it certainly is best if he follows suit. Why is it necessary even to debate a policy for reducing global climate change if we believe that having the planet melt out from under your kids is actually pretty bad, probably the worst outcome imaginable? In this new game there is no excuse for ending up in the global meltdown corner, other than failure to understand the game.

		Longer Time Frame	
		Your Policy	
		Go Green	Don't Go Green
Your Partner's Policy	Go Green	You: \$0 Partner: \$0	You: -\$X Trillion Partner: -\$X Trillion
	Don't Go Green	You: -\$X Trillion Partner: -\$X Trillion	You: -\$X Trillion Partner: -\$X Trillion

Figure 3.—The Longer-Term Environmental Prisoners' Dilemma.

5. Why Even More Realistic Rules for The Planetary Climate Change Prisoners' Dilemma Won't Help

For concreteness we will assume that the two players in the game are China and America. These are the two greatest contributors to global greenhouse gases, with the US the historical largest

contributor both in absolute and per-capita terms, but with the Chinese rapidly gaining on both measures as their economy expands.

Now suppose we have all three rule changes simultaneously. (1) America can talk to the Chinese, we don't have to make our decisions without discussions. (2) We have to play the one-planet game repeatedly, year after year, one coal-fired power plant at a time, or one solar panel energy farm at a time. (3) And catastrophic climate change is not a minor inconvenience; as shown in figure 3, it is *never* the best strategy.

The short-term game is shown in figure 4; once again, the payoff from business as usual is zero, since there is no change from our baseline welfare. Our targeted reductions are taken from Pascala and Socolow (2004), who suggest that stabilization at current atmospheric concentrations of CO₂ through 2050 would require reducing projected growth in fossil *carbon*³ emissions by 7 billion tons annually below the level that would result from anticipated economic growth⁴. The authors argue that this requires a ramping up in carbon emissions reduction from zero billion tons carbon emissions (0GtC) at present to 7GtC reductions in half a century, which they divide into seven stabilization wedges of 1GtC reduction in annual emissions, phased in over 50 years.

We did some crude calculations to determine the costs of achieving one billion tons of reduction in the US and China between now and the middle of the century:

- In order to stabilize atmospheric CO₂ concentrations at 500 parts per million, Pascala and Socolow set the target of reducing new global CO₂ emissions by 7 billion tons over the next half-century.
- With the US and China as the two largest polluters and likely to remain so, we arbitrarily assign to each a goal of $\frac{2}{7}$ of the total, or 2 billion tons annual reduction over the course of half a century⁵.
- We focus initially on one technology of the many proposed by Pascala and Socolow, that of replacing traditional pulverized-coal-fired plants (*stinkers*) with plants powered using coal gasification and CO₂ sequestering technologies (*CGS*).
- Our own calculations closely match those of Pascala and Socolow; they suggest that phasing in 800 GW of electrical power generation capacity based on carbon capture and sequestration to replace traditional coal-fired stinkers would suffice to create a single 1 GtC wedge. Since we assigned 2 wedges as the target for the United States the US will need to phase in approximately 1600 new clean CGS-technology plants over the coming

³ Note that the authors set their target reductions in terms of the weight of fossil carbon released; converting their numbers to reflect total weight of CO₂ would require multiplying all of the weights by approximately 3.7.

⁴ S. Pascala and R. Socolow, "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies," *Science*, 13 August 2004, pp. 968-972

⁵ This leaves the remaining $\frac{3}{7}$ of the reduction for the rest of the world. This rather arbitrary division can be adjusted.

half century.⁶ Assuming that *all* introduction of clean CGS power plants will represent replacement of existing technology rather than new construction and thus that all introduction of new CGS power plants represents capital expenditure aimed at reducing CO₂ emissions, we get a figure of 1600 plants times \$2.2 billion per plant, or a total capital expense of approximately \$3.5 trillion over the next half-century. Figuring on 32 new plants at \$2.2 billion per plant suggests an incremental capital expenditure of about \$70 billion annually. Making the more reasonable assumption that half of this represents new expenditure in the US and half represents regularly scheduled replacement of obsolete infrastructure, the average annual incremental capital expenditure will be approximately \$35 billion. This represents about ¼ of 1% of US of current US GDP⁷. These numbers are not unmanageable.

- We assume that China will be required to remove a comparable amount of incremental carbon emissions, but that the required incremental Chinese capital expenditures would be significantly less. China is currently building new power plants at the rate of more than 30 a year, so at least initially almost all of the required reduction in CO₂ emissions could be achieved without replacing existing plants, but merely by redesigning plants that are already scheduled for construction. Additionally, at present China enjoys construction costs that are roughly one third those of the United States. We assume that the costs to China would represent perhaps one third of those of the US, or \$1.2 trillion over the next half-century. Corresponding first year capital expenditure figures for China would be approximately \$12 billion. These expenditures would also average about ¼ of 1% of (current) Chinese GDP⁸ as well and should likewise be manageable⁹.

There may be other industrial changes that would be more cost-effective, or the cost of coal gasification may decline dramatically as the scale of equipment production increases. The actual game is not changed significantly if these numbers are doubled or are cut in half.

So if the implications of treating cooperation on greenhouse gases can clearly be seen as a monumental, high-stakes version of the prisoners' dilemma, how can we fail to reach agreement, and how can we possibly continue to have an increase in the greenhouse gases that cause long-

⁶ This will require replacing just over half of the existing installed base of approximately 2800 power plants in the US over the next half century; of course, given the lifetime of existing plants, all would have been replaced within this timeframe. Clearly, therefore, not all of the total capital expense represents new expenditure.

⁷ We assume that current US GDP is \$13.22 trillion.

⁸ We assume that current Chinese GDP is \$2.512 trillion.

⁹ These figures may overstate some of the costs associated with reducing CO₂ emissions. Some of the mechanisms for reducing emissions may actually produce benefits, for example, through energy savings resulting from more efficient buildings, more efficient transportation systems, or more efficient power generation. Construction, if it uses economic resources that would otherwise not be deployed, will indeed have economic costs, but it will produce economic benefits through traditional *multiplier effects*. Still other benefits may be achieved through the reduction of American or Chinese dependence on imported oil.

term climate change? The answer is not very complicated: although the 50-year game looks like figure 3, the short-term 2007, or 2008, or even 2015 game has the annual expenditures shown in figure 4.

		Short Time Frame	
		Your Policy	
		Go Green	Don't Go Green
Your Partner's Policy	Go Green	You: -\$35 Billion Partner: -\$12 Billion	You: \$0 Partner: -\$12 Billion
	Don't Go Green	You: -\$35 Billion Partner: \$0	You: \$0 Partner: \$0

Figure 4.—The Short-Term Environmental Prisoners' Dilemma.

The nature of the long-term game is not visible, and in the very-short term, it is better for Chinese and American leadership to ignore green policies, and thus to enable their economies to grow as quickly as possible, to compete internationally as effectively as possible, and to avoid the “unproductive” drains on their economies that investment in pollution control would require. Standards of living increase rapidly, as consumers enjoy larger houses, more meat in their diets, and more gasoline-based transportation. To defend government decisions to avoid going green in the developing world, arguments can be made, such as “global warming is not a proven fact,” or “we pollute far less, or far less per capita, than the West,” or even “historically, all of the pollution causing climate change has been caused by the West, and it is unfair to criticize us now as we attempt to benefit our own people.” Of course, if China is playing out the strategy implied by the rules shown in figure 4, and if American politicians want to get reelected and want a strong US economy, then the American government will also play out this strategy. Indeed, the current American administration has argued that climate change is not proven, that anthropogenic causes of climate change are not proven, and that it would be premature and damaging to the US economy to act now. Taken together, the current Chinese and American environmental policies suggest that the planet is headed for lower right corner again, just as in figure 1 and figure 2, and that we are headed for global meltdown.

Where does this leave us? Obviously, the naïve solution — “they don't trust us, we don't trust them, the rules say we can't talk over our actions, let's both optimize our local economies until we melt down and die” — doesn't look very clever. We can certainly do better. Scientists around the world, working independently, for their national governments, or for international organizations such as the UN, have tried to explain what we need to do, but to date with little effect. We have been unable to turn this standoff into a repeated game with communication and verification, and we continue on track for global meltdown. The April 7 report released by the United Nations suggests that indeed the future is apocalyptic if we continue on our current trajectory, with droughts, floods, and famine. As importantly, it suggests that national governments have consistently manipulated scientists' reports and have denied much of what is

already known about climate change. We appear to be committed to playing the short-term planetary dilemma game in figure 4, not the correct long-term planetary game in figure 3.

6. Averting Environmental Armageddon — Escaping the Climate Change Prisoners' Dilemma

What do we need to know to avoid a long-term catastrophe? Recapping what we have said above:

1. Global warming is real. The impacts of climate change on water resources, on food production, and coastal regions can be estimated with sufficient accuracy to determine that the costs will be enormous.
2. Global warming can be averted, and we know what needs to be done to accomplish this; we can estimate what magnitude of reduction is required in the various sources of CO₂ emissions. Various changes in production, transportation, or consumption will each contribute to the necessary reductions in greenhouse gases.
3. The expense of doing what we need to do is enormous and represents a significant portion of the global GDP, certainly initially measured in hundreds of billions of dollars annually, but it is feasible and less expensive in the long run than inaction.
4. The cost of "*environmental bad behavior*" and continued pollution is borne by everyone *in the long run*, while the benefits are enjoyed by the polluter *immediately*.
5. The attraction of (4) trumps the possibility of (3), especially in the Prisoners' Dilemma setting, in which unilateral good behavior is actually expensive, and bilateral good behavior is not certain to occur.

So what is needed to end the rush towards meltdown? Economists talk about externalities — harm we cause to others while pursuing our own gains. Years ago, when smoking was still legal in most American buildings, an American comic had a marvelous answer when anyone asked him, "*Mind if I smoke?*" He simply replied, "*Of course not, as long as you don't exhale.*" The problem isn't smoking, which is an act that victimizes only the smoker; the problem is exhaling and sharing smoke. Most American city governments have intervened to reduce smokers' rights to impose this externality — their smoke — on their neighbors.

What we need is an international organization prepared to impose the costs of pollution upon polluters, that is, to "*reinternalize the externalities.*" Imagine an agency trusted and empowered by major Western powers to perform CO₂ or NO_x emissions audits on all nations. Those that did not meet strict emissions standards would have import duties imposed on their exported goods and services by the nations that imported them, making these goods and services more expensive to purchase and reducing sales. Since the Western powers are the major buyers of Chinese exports, the imposition of tariffs on polluters would significantly affect at least China. While the United States might argue that the bulk of its pollution was caused by internal consumption (transportation and power generation) rather than by manufacturing for export, the rating agency would be empowered to audit the pollution levels within the United States and to impose appropriate tariffs on America's high-tech exports and exports in services. This would provide incentives for all nations to clean up their production, in order to avoid punitive penalties that

would affect the price of their exports and reduce their competitiveness. Ideally, if properly calibrated, these import duties would never actually be imposed, as nations imposed the necessary clean-up expenses upon themselves to avoid tariffs. The idea of a tax on pollution is, of course, not new, nor is the analysis of problems with imposing such a tax.

But what if nations ignored the fact that tariffs were imposed on their exports and continued stubbornly releasing greenhouse gases? The same agency that performed emissions audits and imposed and collected tariffs would be empowered to spend the resulting revenues wherever they would do the most good. That might mean spending the money in America, to deal with coal-fired power plants, or in Germany. More likely, though, it would result in sending the money to China to be spent on pollution reduction there. If China wanted to sell its exports in any nation that accepted the Global Rating Exports and Emission Negotiations Protocol (GREEN Protocol), it would reduce its emissions of greenhouse gases. If it did not, the tariffs imposed would increase buyers' prices and reduce sales of Chinese exports; the tariffs would increase prices and reduce sales as effectively as if prices had been increased because of increased production costs in China as a result of expenses to reduce emissions, releasing atmospheric pollutants would damage the Chinese economy, and in at least one sense the externality of pollution would have *come home to roost*.

For the US, the choice to reduce emissions itself would be even more clear. If the US wanted to sell its exports, it, likewise, would either reduce emissions or face tariffs. While both would create a drag on the US economy, the tariffs imposed on US goods might be sent to places where the money could be spent most effectively; thus, while the tariffs that were imposed would increase the cost of US exports as significantly as investments in emissions control would have done, the US would not be any greener the following year and would not have earned any reduction in the tariffs imposed. Pollution levels would remain high and tariffs would continue to be imposed. It would be far better for the US to invest in emissions control and work its way out of the imposition of tariffs.

This Green Protocol and its rating agency's ability to design tariffs that would be imposed on the goods of polluting nations would greatly reduce greenhouse emissions and get us into the upper left box of figure 3:

- Polluters clean their production facilities in order to avoid tariffs and to compete effectively
- Polluters have tariffs imposed upon them, and the revenues from tariffs are used to clean up producers wherever it will produce the most gain

Either way, the planet benefits.

These ideas, while attractive, are impractical, for reasons described below.

7. Why a Rating System Alone Won't Work

Our first thought is that the imposition of tariffs should not be necessary; unfortunately, a rating system alone won't work. The issue of long-term climate change is important enough that consumers should be both informed and rational. If so, then consumers will rationally avoid goods that are produced by companies or countries that are known to be major polluters; that if

the rating agency announces a particular company or country as a major contributor of greenhouse gases, a global voluntary consumer boycott will be sufficient to force compliance even in the absence of tariffs to make the "tainted" goods more expensive.

Decades of experience suggest that this has not been the case. In the early 1970s, before sale of leaded gasoline was phased out in the United States, some companies voluntarily sold only unleaded gasoline, but very few consumers abandoned leaded gasoline until forced to do so; even a small price premium for unleaded was more than most consumers were willing to pay for clean air. Similarly, most American consumers have not abandoned traditional automobiles for fuel-efficient hybrids, nor have human rights or environmental complaints against individual manufacturers been successful in changing consumers' purchasing behavior. Indeed, recent studies in the United States suggest that although a majority of citizens now believe that climate change is a serious concern, few are willing to pay higher gasoline price in order to ameliorate this problem. We believe that many Americans are becoming more receptive to the idea that averting catastrophic long-term climate change will require some sacrifice in the short-term, and that these sacrifices are justified; we also believe that it will be difficult to get the necessary consensus among both American citizens and their leaders for these sacrifices if they are not simultaneously made by America's largest trading partners.

8. Why a Rating System and Mandatory Tariffs Won't Work

Our second thought is that the whole idea of a third party setting mandatory tariffs won't work either. Imagine how this would look from the perspective of a US voter, or a US politician:

- China is not investing in environmental quality, lowering their costs of manufacturing and indeed lowering the costs of power generation within China. China has cheaper goods domestically and a higher standard of living than they otherwise would enjoy, precisely because they are not investing in environmental remediation.
- The US is forced to impose tariffs on Chinese goods, making them more expensive in the US and lowering the American standard of living.

Accepting the imposition of these tariffs can be seen both as accepting a reduction in American sovereign rights and a reduction in the American quality of life. Neither will be acceptable, either to American voters or to American politicians.

The problem, as seen from a Chinese perspective, would be similar.

9. Why "I'll Play on Tariffs if You'll Play too" Won't Work

The repeated prisoners' dilemma can be *solved* with the very simple "tit-for-tat" strategy; play nice after your playing partner has been nice, and play nasty after your partner has been nasty. Experimental results confirm that the tit-for-tat strategy for playing a repeated prisoners' dilemma game works better than any other. If you don't confess I won't the next time, and we both win the game, and we can do that time after time, as shown in the upper left box of figure 2. You play nice, and I'll play nice. If you get nasty and betray me and confess, I will do so too the next period, and we're both worse off. Eventually, both parties figure out that they are better off playing nice even if they can't discuss their actions, and the game settles down into repeated profitability for both players.

Unfortunately, if China and America play the equivalent of tit-for-tat in the environmental version of the prisoners' dilemma they will play using figure 4, the short-term game. In the short-term game, the signals we receive allow us and indeed may force us to misinterpret what the *nice* action actually is. We and the Chinese both refuse to remediate our pollution, and we and the Chinese can do this by simply each agreeing to ignore any tariffs that the GREEN rating agency recommends that we impose on the other's imports. "*Let's both pollute*" is, in fact, the strategy we are already playing with the Chinese, and a rating agency with the ability merely to recommend tariffs on the goods of offenders will not change the behavior of either party. Other nations, perhaps Japan or those of the EU, may impose tariffs on goods imported from the US or China, and use the tariffs collected to take remedial actions, but the moneys raised by taxing only their own imports from the US or China may not be sufficient to counter the damage caused by the full range of economic activities of these two nations.

10. Surely there must be a solution?

Actually, there doesn't have to be a solution to the game as we have described it here; in *Collapse*, Jared Diamond reviews the frightening examples drawn from numerous societies that were unable to avoid environmental disaster. Diamond asks, "what were the Easter Islanders thinking when they cut down the last tree, ensuring that they could neither fish nor trade with other Polynesian islands for resources they required?" Did they expect scientists to find hidden reserves of other trees, or to invent tree substitutes? Will future generations ask what *we* were thinking when we ignored data and models, ignored obvious trends in the weather, and caused the polar ice caps to melt? The larger the "island" the harder it is to see the effects of one's own actions and the more actions need to be coordinated, and the Earth is one very large island. It is by no means certain that we will be able to find and to implement a solution.

Although success is not inevitable, neither is failure, and there are occasional bright spots of responsible consumption. Starbucks pays more and purchases environmentally certified coffee, and some shoppers demand chocolate grown and harvested with humane labor practices or tuna caught in ways that do not endanger dolphins. With strong enough consumer preferences, there may indeed be a way to reinternalize the externality of pollution and to place sufficient pressure on major polluting nations to alter their behavior.

Let's call the strategy that we are advocating "assisted tit-for-tat" or "tit-for-tat with a referee." Assume that there is a considerable bloc of nations all of which have accepted a green protocol and agreed to be rated, and moreover that these nations have agreed to impose tariffs on any nation that has not achieved targeted reduced levels of pollution. Assume moreover that this bloc, perhaps the EU plus Japan, Canada, Australia and New Zealand, is large enough to matter to exporters. In that case, the combination of rating and imposition of taxes by parties that have accepted the protocol will modify the behavior of exporting nations, even if they would not otherwise agree to impose tariffs on their own or adhere to green standards.

Now, let's assume that the US, under pressure more from its own citizens than from abroad, has agreed to achieve targeted levels of CO₂ emissions, *if and only if* other trading nations, in particular China, agree to do so as well.

The "assisted tit-for-tat" strategy now plays out as follows:

1. The US acts to stabilize its CO₂ emissions, through some combination of legislation, taxes, tax credits, or whatever programs are designed to induce corporate compliance.
- 2A. China does the same, producing a similar level of reduction, although at considerably lower cost.

OR

- 2B. China does not, and the Green trading bloc enacts punitive tariffs on imported Chinese manufactured goods. The money raised through these tariffs can be invested in pollution abatement.

A tariff increases the price of goods and services sold to any nation that imposes the tariffs, reduces purchases, and reduces the total sales of the polluter's exports; this punishes the producer. Internal investment may also increase the cost of goods, but at least it does so while creating conditions that lead to reduction or elimination of future tariffs. Calibration of this tariff must be left to economists with more data and better models than we have, but the idea is simple; it makes environmentally responsible behavior also economically more attractive. As more nations adhere to the green standards and join the bloc, even if only to stop paying tariffs, the power of enforcement wielded by the bloc will increase.

Will the US be persuaded to act? Are there enough trading nations, like Japan and South Africa that can, along with the EU, act to achieve an assisted tit-for-tat strategy? Or will environmental skeptics and those with a short-term perspective ensure that we all continue with business as usual? The next few years will be critical.