A Paper for the London Accord

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Background

Future history books may well look back on climate change as the greatest challenge facing mankind at the beginning of the twenty first century. Recent attention, such as The Stern Review[1] and Al Gore's An Inconvenient Truth[2], along with much other work, has resulted in an emerging consensus that climate change is a real and present issue. Few people now deny that climate change is happening or deny that human activity is a major contributory cause. The correlation between the amount of fossil fuels burnt and carbon levels in the atmosphere is compelling. There are strong beliefs that the carbon levels in the atmosphere threaten global climate stability. There is a growing belief that international collaboration is needed to reduce emissions of carbon.

Real progress in reducing climate change and mitigating its effects is likely to involve consensus between and the co-operation of four groups:

- governments,
- non-governmental organisations (NGOs), in particular but not exclusively environmental NGOs,
- international bodies such as the UN,
- commercial organisations, in particular large, international corporations.

The Kyoto protocol, the UN's existing treaty on climate change, the result of a series of summits, shows how difficult it is to create consensus amongst different interest groups. Kyoto expires in 2012 and efforts to build a replacement are underway. Several conflicting viewpoints exist, two of the most prevalent can be summarised:

[1] Sir Nicholas Stern, *Stern: The Economics of Climate Change*, HM Treasury, 2006, http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm

[2] An Inconvenient Truth, Al Gore, Viking Juvenile, 2007, ISBN 0670062715. Film/DVD Dated 2006.

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- rich countries must cut their emissions of greenhouse gases, whilst developing countries continue to grow their economies, and hence their carbon emissions, **unless** rich countries pay the developing countries to use 'greener' technologies;
- disseminating 'greener' technologies is fundamental and any solution must involve developing countries as well as richer ones.

Underlying these viewpoints is another inconvenient truth; no government is likely to tackle climate change alone. As the Economist put it[3]:

> *At any given summit on climate change, it is never long before some politician declares how "urgent" or "vital" or "imperative" it is to stop the planet from overheating. And as yet few governments are willing to tackle the problem by themselves. In practice, what these impassioned speakers usually mean is that it is urgent – no, vital! – no, imperative! – for all countries* ***but their own*** *to get to grips with climate change.*

The Theories

Climate change negotiations are a classic example of the **Tragedy of the Commons**. This is a type of social trap that involves a conflict over resources between individual interests and the common good. The name of this tragedy comes from difficulties farmers had in the past with overgrazing their sheep on mutually owned or "common" land. It benefited a farmer to put as much livestock as he could on common land, even if it eventually became less productive because of overgrazing. The principle explains the root causes of the difficulties in solving many multilateral, international and/or resource allocation problems, not only climate change but also other present day problems such as over-fishing or tax avoidance.

It is too often assumed that the only way of managing common resources is via government. The academic arguments began when Hardin [1968][4] reified the "tragedy of the commons" using a number of topics, such as pollution and overpopulation, to illustrate his point that we needed to submit to "mutual coercion" on our activities in former areas of freedom such as waste disposal or breeding. Hardin's influential paper has polarised subsequent debate.

[3] The Economist, *'Playing Games with the Planet'*, Page 99, September 29th 2007.

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At one extreme of the debate, public assets must be publicly governed. Coercion via government is a natural enforcement mechanism, and ultimately all use of public resources must flow from government. At the other extreme, only by allocating property rights over formerly public assets will people care enough, in their own selfish interest, to defend and maintain assets. Are the old battle lines being redrawn - socialism or capitalism?

The tragedy of the commons relates to climate change because all countries share the same atmosphere. All countries will therefore benefit from a stable climate whether they have helped to bring it about or not. If a government can persuade others to cut greenhouse gas emissions without cutting its own then it can enjoy the benefits without paying the costs. If, however, everybody expects others to act then it is likely that nobody will act. If nobody acts, the situation will be worse than if everybody had co-operated in the first place.

Game Theory[5] emerged to help theorists grapple with problems of multilateral behaviour between agents with varying motivation. As Game Theory developed, economic variants emerged searching for rational behaviour and equilibria to solve problems[6], and a great many different types of game were used, depending on the problems involved[7].

The tragedy of the commons is, in effect a 'multiplayer version' of the well known **Prisoner's Dilemma,** one of the better-known Game Theory games. In the prisoner's dilemma, two prisoners accused of the same crime are locked in separate cells and cannot communicate with each other. Their captors try to persuade each to implicate the other. If neither implicates the other, each gets a one year prison sentence. If one prisoner implicates the other, he goes free whilst the implicated prisoner gets a ten year sentence. If both prisoners implicate each other, they both get five year sentences.

[4] HARDIN, Garrett, "The Tragedy of the Commons", Science, 162, pages 1243-1248, 1968.

[5] von Neumann, John, and Oskar Morgenstern (1944). *Theory of Games and Economic Behavior* Princeton University Press, although von Neumann's Zur Theorie der Gesellschaftspiele covered much of the ground earlier, in 1928

[6] Nash, John (1950). "Equilibrium points in n-person games", *Proceedings of the National Academy of the USA* 36(1):48–49.

[7] Poundstone, William (1992). *Prisoner's Dilemma: John von Neumann, Game Theory and the Puzzle of the Bomb*, ISBN 0-385-41580-X (a general history of game theory and game theoreticians)

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		Prisoner A	
		Keeps quiet	**Implicates prisoner B**
Prisoner B	**Keeps quiet**	A and B both get a one year sentence	A is set free, B gets a ten year sentence
	Implicates prisoner A	A gets a ten year sentence, B is set free	A and B both get five year sentences

Whatever one prisoner does, the other is better off if he implicates his fellow prisoner - if one's fellow prisoner keeps quiet and one implicates him, one goes free. If your fellow prisoner implicates you and you implicate him, you get a five year sentence rather than a ten year sentence if you keep quiet. Logical behaviour is thus likely to lead to both prisoners getting five year sentences. If, however, the prisoners trusted each other they would both keep quiet and both would only get a one year sentence.

Situations similar to the prisoner's dilemma occur during climate change negotiations. Michael Liebreich[8] compares climate change negotiations to the prisoner's dilemma and suggests that the Stern Review even provides values for the payout table. If the world takes action now, Stern estimates a cost of 1% of per capita, per annum GDP. If the world does nothing, the cost will be between 5% and 20% of per capita, per annum GDP.

As Liebreich points out however, climate change negotiations are not a 'one-off' prisoner's dilemma but take place repeatedly and countries will change their strategy in response to the actions of others in previous 'rounds' of negotiation. Previous work on iterated prisoner's dilemmas[9] suggest four rules to follow for the best outcome:

- Be Nice - start by cooperating, and never be the first to defect;
- Be Retaliatory - if the other player defects, inflict a cost on him;
- Be Forgiving - if your opponent mends his ways, restore cooperation as quickly as possible;
- Be Clear - there is no way to beat the Nice, Retaliatory and Forgiving strategy, so if your opponent knows your intentions in advance there is no benefit in not co-operating.

[8] M. Liebreich, *How to Save the Planet: Be Nice, Retaliatory, Forgiving and Clear*, New Energy Finance, September 2007
[9] University of Michigan, , *The Evolution of Cooperation,* Robert Axelrod, 1984

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Liebreich suggests that this can be applied to international climate change negotiations:

- Be Nice - sign up to unilateral cuts in emissions;
- Be Retaliatory - identify players who have not begun to take action and, in cooperation with others, find ways of hurting them until they do so;
- Be Forgiving - when recalcitrant countries do come in from the cold, no matter how obdurate they have been, welcome them with open arms;
- Be Clear - let everyone know in advance exactly how you are going to behave.

There are, as Leibreich points out, a number of limitations to this analysis. These include asymmetry (not every country has the same to gain from mitigating climate change or the same costs); non-linear effects (defection by one or both players increases the cost of climate change); cumulative effects (payoffs from successive rounds of climate negotiations are not independent, since carbon accumulates in the atmosphere); multi-player dynamics; the possibility of alliances and political factors.

The tragedy of the commons usually has worse results than a simple prisoner's dilemma because there are a greater number of players. There are two reasons for this:

- the total reward generated by each player decreases with the number of players – with more players, the 'risk/reward' or cost/benefit equation for non-collaborators is more favourable:

Number of players	**Do we pay the economic cost of combating climate change? (assuming everyone else does)**	
	If we pay:	**If we don't pay:**
3 Players	Cost of x and benefit of y	Cost of 0 and benefit of 2/3 y
10 Players	Cost of x and benefit of y	Cost of 0 and benefit of 9/10 y

- the more players there are, the harder it is to have good and trusting relationships with them all - there is a greater chance that one will defect.

Prospect Theory[10], for which one of the proponents, Daniel Kahneman, won a Nobel prize in 2002 (sadly, his colleague Amos Tversky had died), is also likely to help understaning international negotiations. Prospect theory was developed to describe how people make

[10] Kahneman & Tversky, *Prospect theory: An Analysis of Decisions under Risk,* Econometrica, 47, pages 313-327, 1979.

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choices in situations where they have to decide between alternatives that involve risk (e.g. in financial decisions). The theory describes how individuals evaluate potential losses and gains. One of the main conclusions of an advanced version of Prospect Theory[11] is that people tend to think of possible outcomes relative to a certain reference point (often the status quo) rather than to the final status, a phenomenon which is called framing effect. Moreover, they have different risk attitudes towards gains (i.e. outcomes above the reference point) and losses (i.e. outcomes below the reference point) and care generally more about potential losses than potential gains (loss aversion). This can be applied to countries in the context of climate change – countries that feel they are 'winning' (not being affected too badly by climate change and not having to spend too much on preventing climate change) are generally more risk averse and not winning to spend so much in the future. Countries that think they are already adversely affected by climate change may tend to take riskier decisions and perhaps spend more to avert climate change or defend against the consequences.

WarmGame

While there is merit in debating the tragedy of the commons, the prisoner's dilemma and prospect theory in the context of climate change, we wanted to see how well these theories might, or might not, work in a simulation. We therefore developed WarmGame, a role playing game that examines some of the political difficulties countries might have in attempting to tackle climate change. The game was designed, not to be a tool that predicts accurately how much carbon might be produced, or how much the global temperatures might rise. WarmGame was designed to illustrate the **political** difficulties countries have now and will have in the future.

The game recognises the real-world complication that countries are not symmetric:

- Some countries suffer more from global warming than others (Russia may even gain from a small amount of global warming, as some of Siberia becomes more productive).

- China and India, have rapidly growing economies and hence rapidly growing demands for power. Other countries' demand for power is fairly static. China and India will suffer more than others from "Status Quo" agreements;

[11] Amos Tversky and Daniel Kahneman. Advances in prospect theory: Cumulative representation of uncertainty. Journal of Risk and Uncertainty, 5:297–323, 1992

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- although the USA is the greatest producer of carbon dioxide, other countries such as Russia and India may be more wasteful in their use of energy;
- China, the EU and the USA have strong sanctioning power and can damage other economies substantially if they want to sanction them;
- Japan depends on oil, but may be the most capable of modernising and moving to renewables;
- the current populations of the countries are approximately: China – 1.3bn; India – 1.1bn; the EU – 458m; the USA – 300m; Russia – 143m; Japan – 127m.

All these asymmetries make it harder to come to an international agreement.

However, the WarmGame is designed as a game and contains many simplifications. One simplification is that the game players focus on the roles of governments, bundling the behaviour of global businesses, consumers, NGOs and International bodies into the concept of "well being" points in a nation state framework. We justify these simplifications because, in order to be effective, the game has to be interesting, not too much like hard work, with easily understood rules and playable in a short timeframe. Without these simplifications, and thus limitations, the game would be hard to play in practice and would be less often played. Learning would be limited. Such constraints imposed disciplines on the game design, but these simplifications enable players to concentrate on what is the heart of the game, the ability to make or break international deals.

WarmGame has been played in a number of venues for a number of different audiences. Z/Yen has used it during several networking events, it was played at the London Accord Conference and it has been used for a teambuilding event at the Carbon Trust.

Strategy

When playing WarmGame, it soon becomes apparent that the tragedy of the commons exists – so, unfortunately, the surest way to win the game is to do **as little as possible to counteract global warming yourself**, but to **ensure that everybody else does as much as possible, while not sanctioning you**. In that way you will not pay the cost of reducing global warming, but the consequences of global warming for you will be small. However –

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if everyone adopts this strategy then everyone loses, as the earth will be overwhelmed by global warming – a good example of the tragedy of the commons and the prisoner's dilemma in action.

Investment decisions are tricky and expensive – if you can get international agreement then investment in energy efficiency or non-fossil fuel power are good investments. If you cannot get agreement then defences to reduce the effect of global warming are seen as preferable. Cooperation and coercion are likely to be the best way to succeed. The threat of sanctions might keep countries in line, but sanctions generally hurt both sides.

Results

WarmGame has now been played a great many times, although the game has evolved somewhat based on learning gained from playing early and pilot versions. WarmGame was designed to illustrate political difficulties, rather than a way of making accurate predictions. However, based on a representative sample of games (of the current version of WarmGame):

Factor	Maximum	Minimum	Mean
Winning score	38 points	19 points	30 points
Losing score	3 points	-239 points	-71 points
Mean score	17 points	-26 points	-5 points
Temperate rise by 2077	2.1^{o}C	1.6^{o}C	1.8^{o}C
Total investment costs	63 points	39 points	55 points
Investment % in own country	54 %	32 %	46 %
Defence investments % of total	51 %	22 %	33 %
Mean investment by country	USA	EU	-

From the sample of games analysed, we notice that:

- games where collaboration was poor (indicated by greater than five sanctions being imposed throughout the game) resulted in higher predicted temperature rises by 2077 – an average of a 1.91^{o}C increase against a average 1.73^{o}C degree increase where some collaboration took place;

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- games where collaboration was poor (again indicated by greater than five sanctions being imposed throughout the game) resulted in countries investing more heavily in defences rather than in reducing emissions – an average of 19.3 investments in defence against an average of 17.0 where more collaboration took place;
- games where collaboration was high (indicated by less than 50% of total investments being made in 'own' countries) resulted in countries investing less heavily in defences– an average of 15.5 investments in defence against an average of 19.5 where less collaboration took place. In the games with higher collaboration, the predicted temperature rise by 2077 was lower (1.75^{o}C) than in the games with lower collaboration (1.85 ^{o}C);
- collaboration encourages investments – games with greater than 12 identified collaborations averaged 62 investments per game, games with fewer than 12 investments average just 51 investments per game;
- the country that imposes sanctions most heavily normally comes last (this occurred in all games bar one).

A number of common factors emerge from the games we have played:

- WarmGame clearly demonstrates the difficulties in establishing effective international co-operation. In all the games played to date, there have been no examples of a six country multi-lateral agreement. There have been a number of bi-lateral and a few tri-lateral agreements;
- in all games to date the predicted effects of global warming were reduced, but by less than they could have been with greater co-operation;
- there have been few really bad or malicious moves, although there was a strong temptation to renege on proposed deals;
- WarmGame also illustrates one of the perceived advantages of defences to mitigate the effects of Climate Change. Whereas cutting down carbon emissions is a benefit to everyone in the world, building defences has a strong benefit to the team who build them, but no benefit to anyone else. If no international agreement is reached, money can still be spent on defences for the immediate benefit of the investing country. Most teams realised this in the latter part of the game, after international agreements had proved so hard.

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Lessons

What does this game teach us? Overall, we can conclude that:

- multilateral negotiations are hard;
- when international power blocks are not symmetric this makes negotiations even harder;
- even if the whole world cannot co-operate, some co-operation, even between two parties, is likely to be beneficial;
- even when little co-operation is agreed, countries can partially mitigate the effects of global warming by investing locally in defences such as flood barriers;
- it can be more cost effective or expedient to invest resources in countries other than your own to achieve desired results;
- investments tend to be heavily influenced by politics, not just investment appraisal;
- WarmGame (and therefore we can probably deduce global climate change) is subject to the tragedy of the commons;
- Prospect Theory does seem to apply to decisions made; when teams feel that they are "winning" they become very risk averse and reluctant to do anything, whereas players who feel that they are losing are far more likely to make more risky collaborations or investments;
- mechanisms and rewards that emphasise, even overweight, investment in other countries may help to shift a move to preventing climate change over investing in defences.

Teams found it very hard to make significant multilateral agreements and in the real world, governments appear to have the same problem. Because of the difficulties in getting international agreements in place, WarmGame indicates to us that mitigating the effects of climate change rather than preventing climate change will be a popular investment option. We might expect to see local projects to mitigate the effects of global warming take place. Dams, canals and irrigation systems might proliferate and towns and cities might enhance flood protection rather than reduce GHG emissions. These investments do not involve the tragedy of the commons, they are costs to a country that buys benefits for that country alone. 'In-country' investments may be easier to justify and more enthusiastically implemented than measures to prevent climate change.

The Mechanics of WarmGame

So, how is the game played?

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Who - the game is played by six teams – each is the government of a country (or in the case of the EU, a group of countries) – India, Russia, USA, China, EU and Japan.

What - each team is given 75 "well being" points to start with. These represent, in a fairly abstract manner, the wealth, the patience and the contentment of the population with the government. These points can be lost by investment, by sanctions from other teams and as a consequence of global warming. The aim of the game was to keep your score above zero by the end of the game. The only way to gain points was to answer questions on global warming. Two questions are asked in each round. A correct answer to a question represents the wise and astute government of the countries, thus giving bonus points.

How - there are four rounds (typically lasting 15 minutes or so each in the situations the WarmGame has been piloted). The first three rounds each represent 10 years, but the last round represents 40 years – the investments made in the final round carry on for the equivalent of four earlier rounds. In each round teams have a simple form to complete. A sample is shown below:

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EU

INVESTMENTS / SANCTIONS		Target Country: India	Russia	USA	China	EU	Japan
Investments	**Build Non Fossil Power Station** (produces one extra unit of energy without CO2)						
	Energy Efficiency (reduce the amount of CO2 produced per fossil fuel burnt)						
	Defences (reduce the economic consequences of global warming)						
Sanctions (Causes a Penalty of **4** to the country sanctioned)							

Please tick the boxes to indicate the investments or sanctions you wish to make – you can only tick once in any box. You can tick as many boxes as you wish but the marginal cost of investments increases with the number of ticks.
The first tick gives a one point penalty, the second tick gives an extra two points penalty (for a total of three), the third tick gives an extra three (for a total of six) etc.etc.

GLOBAL WARMING KNOWLEDGE

Question 1: In the UK today, nearly 5 million tonnes of paper is dumped in landfill or incinerated every year. Recycling one tonne of paper saves how much fresh timber (source: Raven Recycling Society)

- ❑500 Kilograms
- ❑800 Kilograms
- ❑1,100 Kilograms
- ❑1,700 Kilograms

Question 2: In 2001 Z/Yen developed the Fishy Bourse game for the Marine Stewardship Council to help people understand certification and sustainable fishing. This game was played at:

- ❑Davos under the auspices of the World Economic Forum
- ❑St James's Palace under the auspices of Prince Charles
- ❑Camp David under the auspices of Al Gore
- ❑Anchorage, Alaska under the auspices of Mayor Mark Begich

Each team must mark on the form:

- the **investments** they want to make;
- any **sanctions** they wish to apply to other countries;
- the answers to the two **global warming knowledge** questions.

There are three types of **investment** that can be made. Investing in reducing global warming in the long-term, costs economic well-being in the short-term (e.g. investing money in wind farms means there is less to invest in hospital beds):

- building non-fossil fuel power plants (e.g. wind, tidal, geo-thermal or solar). These plants emit less carbon dioxide than fossil fuel plants;
- investing in energy efficiency. These investments reduce the carbon dioxide produced for each unit of energy produced or consumed);
- investing in defences (e.g. sea defences, dams, and canals). These investments reduce the consequences of global warming, but do not affect global atmospheric carbon levels.

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Each team can only invest once (per round) in each of the three investment types in any one country. They can invest in as many projects as they feel that they can afford within any round – but the cumulative costs of investment within a round rise steeply. They can also apply economic **sanctions** to one or more countries in each round. Different countries have different economic power (being sanctioned by China costs 6 well-being points, being sanctioned by India only costs 2 points). In the final round, sanctions are automatically reciprocated.

Global warming knowledge questions give players an opportunity to gain well-being points and represent the competence and knowledgeable leadership of each government. Knowledge of global warming issues gains two well-being points for each correct answer.

The key to WarmGame is to conduct successful multilateral negotiations on who should invest in what and when.

Scoring – each team receives a score sheet at the end of each round. A sample of the score sheet is shown below:

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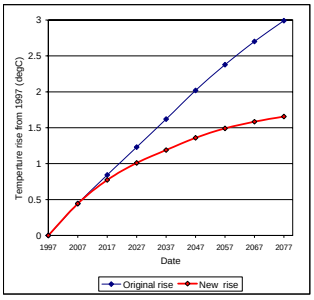
FINAL SCORES (2077)

Country	Energy Expenditure: Non-Fossil	Energy Expenditure: Fossil	Energy Efficiency Level (CO2 per fossil)	CO2 Produced	Defence Levels		Global Warming	Investment Costs	Sanctions	Global Warming Knowledge	Well Being Points Total
India	10	16	25	400	2	Round 7	-12	-1	0	0	-13
						Total	-60	-25	0	2	-8
Russia	7	13	30	390	6	Round 7	-3	-1	0	2	-4
						Total	-18	-27	0	8	38
USA	5	25	25	625	6	Round 7	-3	-3	0	0	-6
						Total	-27	-30	0	2	20
China	16	12	25	300	6	Round 7	-5	-3	0	2	-8
						Total	-44	-40	0	6	-3
EU	4	16	30	480	5	Round 7	-4	-3	0	2	-7
						Total	-37	-27	0	6	17
Japan	5	5	25	125	5	Round 7	-4	-10	0	0	-14
						Total	-35	-55	0	6	-9

CO^2 produced	2,320
Previous CO^2	15,830
10% CO^2 absorbed	-1,583
Cumulative CO^2	16,567
Temperature rise	1.7 °C
Predicted temperature rise by 2077	1.7 °C
Predicted temperature rise by 2077 (start of game)	3.0 °C



Who Built	What Built	Where Built: India	Russia	USA	China	EU	Japan
India	N/F Power	✓✓••	••••	••••	•✓••	•✓••	••••
	Efficiency	✓✓•✓	•✓••	••••	••••	••••	••••
	Defences	••✓•	••••	••••	••✓•	••••	••••
	Sanctions		••••	••••	••••	••••	••••
Russia	N/F Power	••••	✓✓✓•	••••	••✓•	••••	••••
	Efficiency	••••	✓✓••	••••	•✓••	••••	••✓•
	Defences	••••	•✓✓✓	••••	••••	••••	••••
	Sanctions	••••		••••	••••	••••	••••
USA	N/F Power	•✓••	••••	✓•••	✓•✓•	••✓•	••••
	Efficiency	••••	•✓••	••✓•	••••	••••	•••✓
	Defences	••••	••••	✓✓•✓	••••	••••	••••
	Sanctions	••••	••••		••••	••••	••••
China	N/F Power	•✓•✓	••✓•	••••	✓✓✓•	••••	••••
	Efficiency	••••	•✓••	••••	✓✓••	•✓••	••••
	Defences	••✓•	••••	••••	••✓✓	••••	••••
	Sanctions	••••	••••	••••		••••	••••
EU	N/F Power	•✓••	••••	••••	•••✓	••••	••••
	Efficiency	✓•••	••••	••✓•	✓✓••	✓•✓•	••••
	Defences	••••	••••	••••	••••	••✓✓	••••
	Sanctions	••••	••••	••••	••••		••••
Japan	N/F Power	••••	••✓•	✓✓••	•••✓	••••	••✓✓
	Efficiency	•✓••	••••	•••✓	•✓••	••••	••✓•
	Defences	••••	••••	••••	••••	••••	✓••✓
	Sanctions	••••	••••	••••	••••	••••	

This score sheet shows, for each country, the current energy demands, the amount of carbon dioxide produced, the investments and sanctions made in the previous round, the effects of global warming and the global warming knowledge points earned in the last round. The score sheet also shows the well-being points each country has and, crucially, the collective effect that their actions have had on the environment in terms of carbon dioxide emissions and the predicted temperature rise at the end of the game.

Conclusions

The tragedy of the commons and the prisoner's dilemma do illuminate the nature of climate change negotiations. WarmGame gives some indication of the difficulties involved in attempting to forge a multilateral agreement on climate change between the big carbon producers. WarmGame demonstrates to players how these difficulties can occur, why different countries have different viewpoints and why these difficulties need to be overcome. Having completed many simulations of climate change negotiations, we are

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convinced that, as hard as they are to accomplish, multilateral agreements to address the problem of climate change will be the only way to make a meaningful difference.

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