The Practice of Climate Change Scientists in the UK and US;
Money, Scientists and Climate Change

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The candidate confirms that the work submitted is her own and that appropriate credit has been given where reference has been made to the work of others

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Abstract

Anthropogenic climate change is a potentially serious ecological problem. The science of climate change is complex, uncertain and contested. This combined with the scale of its potential terrestrial impacts has ensured that the topic remains the focus of debate amongst scientists, politicians and the wider public. The importance of climate science, and of climate scientists as experts informing the policy process, has contributed to the controversy that surrounds the production of scientific knowledge in this field. Previous studies have claimed that climate science has been unduly influenced both by external vested interests and the inappropriate emphasis placed by some climate scientists themselves on securing continued research funding. Against this background the thesis explores the funding of climate change research in the UK and USA. In this it pays particular attention to the attitudes and experiences of climate change scientists themselves through a study of their accounts of the process of obtaining research funding.

The thesis begins by reviewing the development of climate change science since the start of the 20th century, with particular attention to its progressive politicisation in recent decades. This introduction to the empirical focus of the thesis is complemented by an exploration of previous theoretical expressions of the relationships between science and scientists, and wider society. A neo-Marxist approach is advanced as a potential theoretical foundation for the thesis. The implications of this approach for research methodology are next outlined.

Interviews with US and UK climate change scientists and associated social commentators provide the basis for a more detailed exploration of their perceptions of relationships in practice between climate change science and wider societal forces. These accounts focus in particular on the availability of research funding and its distribution between researchers adopting different scientific positions on climate change. Government and business are highlighted as important influences upon the scale and distribution of financial support for climate change research – and by extension upon the conduct and content of climate change science.

Abstract

The interviews also suggest, however, that climate scientists feel at least some degree of freedom from their paymasters; a perception not exclusively confined to a small elite of leading scientists. Processes of bidding for funding, and research review and dissemination allow scientists to engage in strategic behaviour to secure support for research that addresses their own interests. Furthermore, the continuing debate between scientists about the reality, causes and scale of anthropogenic climate change of itself helps to maintain funding for research in this field.

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Abbreviations

AGGG	Advisory Group on Greenhouse Gases
AOSIS	Alliance of Small Island States
BBC	British Broadcasting Corporation
BBSRC	Biotechnology and Biological Sciences Research Council (UK)
BP	British Petroleum
BSE	Bovine Spongiform Encephalopathy
CAN	Climate Action Network
CFC	Chlorofluorocarbons
CO_2	Carbon Dioxide
COP	Conference of the Parties to the United Nations Framework Convention on Climate Change
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DOA	Department of Agriculture (US)
DOE	Department of Energy (US)
DOD	Department of Defence (US)
DTER	Department for Transport, Environment and the Regions (UK)
EIA	Energy Information Agency
EPA	Environment Protection Agency (US)
ESRC	Economic and Social Research Council (UK)
EPSRC	Engineering and Physical Science Research Council (UK)
EU	European Union
EPA	Environmental Protection Agency (US)
FCCC	Framework Convention on Climate Change
FOE	Friends of the Earth
FY	Fiscal Year
GCC	Global Climate Coalition

Abbreviations

GCM	General Circulation Model
GCR	Global Climate Research
GCMI	George C Marshall Institute (UK)
GMO	Genetically Modified organisms
GM	Genetically Modified
GW	Global Warming
HEFC	Higher Education Funding Council (UK)
ICSU	International Council for Scientific Unions
IEA	Institute of Economic Affairs (UK)
IGY	International Geophysical year
IGFA	International Group of Funding Agencies
INC	Intergovernmental Negotiating Committee or a Framework Convention on Climate Change
IPCC	Intergovernmental Panel on Climate Change
MET Office	Meteorological Office (UK)
MIT	Massachusetts Institute of Technology (US)
MRC	Medical research Council (UK)
MOD	Ministry of Defence (UK)
NAS	National Academy of Sciences (US)
NASA	National Aeronautic and Space Administration (US)
NERC	Natural Environment Research Council (UK)
NGO	Non-governmental Organisation
NHI	National Institute for Health (US)
NOAA	National Oceanic and Atmospheric Administration (US)
NSF	National Science Foundation (US)
NUDist	Non-numerical Unstructured Data indexing, sorting and theorising

OPEC	Organisation of Petroleum Exporting Countries
PSAC	President's Science Advisory Committee (US)
QUANGO	Quasi-autonomous Non-governmental Organisation
RAE	Research Assessment Exercise
RSPB	Royal Society for the Protection of Birds
SCEP	The Study of Critical Environment Problems
SEPP	Science and Environment Policy Project
SI	Smithsonian Institute (US)
SMIC	The Study of Man's Impact on Climate
SO_2	Sulphur Dioxide
TOA	Top of Atmosphere
UNCHE	United Nations Conference on Human Environment
UNEP	United Nationals Environment Programme
UNFCC	United Nations Framework Convention on Climate Change
USGS	US Geological Survey
USGCRP	US Global Climate research Program
WCED	World Commission on Environment and Development
WEFA	Wharton Economic Forecast Associates (US)
WGI	Working Group I of the Intergovernmental Panel on Climate Change
WGII	Working Group II of the Intergovernmental Panel on Climate Change
WGIII	Working Group III of the Intergovernmental Panel on Climate Change
WMO	World Meteorological Organisation
WWF	World Wildlife Fund/World-Wide Fund for Nature
WWW	World Wide Web

CHAPTER ONE

Introduction

1.1 Setting the Scene

1.1.1 The Importance of Climate Change

Anthropogenic climate change, or 'global warming' is a potentially severe ecological problem. The science of climate change is complex, uncertain and contested, and this, combined with the scale of its potential terrestrial impacts and the associated threat to established socio-economic systems, has ensured that the topic remains the focus of continuing debate amongst scientists, politicians and the wider public. Indeed, climate change is an issue that is 'hard to grasp through scientific inquiry and hard to address with political measures' (Krueck and Borches, 1999, p.105). It is also an area in which society at large is particularly dependent on the understanding developed by a relatively small group of scientific 'experts'.

Opinion, both within the scientific community and society as a whole, remains divided about the reality of global warming, its causes and likely consequences. At its simplest the climate debate can be viewed as a contest between two opposing camps. One is informed by the understanding of 'protagonist' scientists, who believe that there is good evidence that increasing concentrations of greenhouse gases in the earth's atmosphere, resulting from human activity, are causing climate change. The other draws on the work of 'contrarian' scientists, or sceptics, who question the evidence and the existence of anthropogenic climate change. The reality of the climate debate is, of course, more complicated, with many different shades of opinion represented, rather than two polar opposites.

Greenhouse gas emissions caused by the burning of fossil fuels are now widely regarded as central contributors to anthropogenic climate change, as they trap outgoing thermal radiation, thus warming the Earth (Drake, 2000). Since the onset of the Industrial Revolution in the late 18th century, humanity's dependence on such fossil fuels has grown significantly. Human development has increased energy demand, in turn amplifying our potential to alter the global environment. It follows that those developed countries with a strong carbon-based economy – including the USA, Japan

and the states of Western Europe – are generally identified as having made the greatest historical contribution to raising atmospheric levels of greenhouse gases, and thus to climate change. Yet this attribution of responsibility has provoked further tensions. There is no international consensus as to how to respond to the apparent threat of climate change. Global warming is seen by many to present a real challenge to the continued expansion of established socio-economic systems. A radical change in the basis of economic development – and specifically energy production – is therefore advocated. This may not only head off environmental disaster, but also open up new markets and investment opportunities in fields such as sustainable energy. Yet those who question the certainty of anthropogenic climate change claim to see no logic to economic and technological reforms which, they argue, will sacrifice economic growth and social welfare.

1.1.2 The Policy Response to Climate Change

For any action against climate change to be effective it must be executed at an international scale, as well as national and local levels. This increases the importance of securing greater consensus on both climate science and climate policy. Mounting concern about climate change, therefore, inspired the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) to establish the Intergovernmental Panel on Climate Change (IPCC) in 1988. This new body was charged with examining the unfolding scientific evidence on climate change and producing a report every five years that would brief world leaders about the current state of scientific understanding. This scientific endeavour also had a political counterpart; the United Nations Framework Convention on Climate Change (FCCC) launched at the Rio Earth Summit of 1992. States that became parties to the FCCC committed themselves, at least in principle, to the stabilisation of greenhouse gas concentrations 'at a level that would prevent dangerous anthropogenic interference with the climate system' (Vrolijk, 2001, p.252). This marked the beginning of attempts to support this commitment through a system of international regulation. The Kyoto Protocol of 1997 set supposedly binding targets for emission reduction by the most developed states of a basket of six greenhouse gases. The average reduction planned was 5.2% by 2008-12. This was to be achieved through a series of more specific targets, involving, for example, a 7% cut in US emissions and an 8% reduction by the EU (UNFCCC, 1997). However, subsequent discussions on the implementation of the

Protocol, most notably at The Hague in November 2000, ended in stalemate. The eventual agreement secured in the absence of the USA, at Bonn in July 2001 and Marrakech in October 2001, have been criticised as weak by environmentalists (Hare, 2001). But even the modest targets for emission reduction set out in the Kyoto Protocol seem unlikely to be met. Thus, the issue still poses a potentially serious global threat. Significantly, lack of complete scientific certainty regarding climate change has contributed to the political wrangling over the Kyoto Protocol. Governments opposed to regulation of greenhouse gas emissions, not least the United States – especially since the arrival of George W Bush in the White House in 2001 – have in part justified their stance by questioning the reality of climate change.

1.1.3 Colliding Worlds – Science, Society and Money

Contest over policy thus reflects the nature of climate science *per se*, but also the potential involvement of vested interests in the overlapping scientific and political debates. Indeed, scientific controversy is further reinforced by the presence of a diverse range of potential funding sources for climate research. Where science is sponsored by actors with a particular interest in the outcome it is hardly surprising that accusations have been levelled about a loss of scientific objectivity.

Claims made by several previous authors, including Beder (1997, 1999), Rowell (1996), Karliner (1997) and Gelbspan (1998) suggested that the research agenda of contrarian scientists has been affected by the financial support of fossil fuel and automobile companies. Such business interests allegedly have a particular interest in playing down the seriousness of global warming, in a context where climate policy seems to threaten their short-term commercial growth. By contrast, Boehmer-Christiansen (1994a, 1994b, 1997 and forthcoming; see also Morris, 1997; Singer, 1998) have questions the objectivity of climate protagonists, including leading figures in the IPCC. She claims that in presenting climate change as a real and serious threat they over-state the extent of the problem. But more than this, it is asserted that their motives for doing so are in part self-interested, reflecting a desire to attract further funding for their own research. Boehmer-Christiansen (1996) also suggested that other parties, including environmentalists, promoters of renewable energy technologies and insurance

companies, may have their own motives for encouraging climate scientists to exaggerate the scale and certainty of the threat associated with global warming.

Such studies raise important questions not only about the funding and reliability of climate science, but also about the roles played by climate scientists. In a context where external interests arguably play an important role in shaping the research agenda through their funding of particular types of project it may be tempting to view scientists themselves as essentially passive figures – as little more than the 'tools' of external sponsors. This is, indeed, not inconsistent with the view put forward by some economic reductionist Marxist models of the relationship between science and the determining forces of a dominant economic substructure (as discussed in Hessen 1971; Rose and Rose 1976). Such theoretical arguments that a capitalist economy necessarily produces a capitalist science have, however, been subject to increasing challenge in recent decades (as discussed in Bunge, 1991; Sohn-Rethel, 1975; Abraham, 1995). In cases such as climate research we cannot simply assume that scientists are allowing their expertise to be 'bought' in this way.

It is possible that scientists themselves are actively involved in setting – and perhaps distorting – the agenda for research and funding. In its own way expert knowledge can be a source of influence and for an elite of scientists this may be reinforced by an ability to shape the thinking of others through publications, public speaking, political lobbying and media appearances. On the surface, at least, such activity may appear justified as a means to ensure that the limited funds available for research are directed towards addressing those issues that are scientifically most interesting and socially most relevant and useful. But, of course, assessments of the interest and relevance of particular research rest on value judgements that reflect the perceptions of individual assessors – including scientists themselves. Their individual interests may, for example, be best served by defining the research agenda in ways that maximise opportunities for securing further funding for their own particular work. Any such charges of the pursuit of self-interest or collaboration with external agencies are potentially serious – not just as a specific distortion of the scientific agenda, but also because they strike at the very basis of claims of scientific worth and credibility as a privileged means of understanding the world.

1.1.4 A Focus on Climate Change Scientists

If the activities of climate change scientists are themselves a focus of contention it follows that there is a pressing need to improve our understanding of the actions and motives of such scientists. The charges laid against particular groups of researchers form the starting point for the current study, which takes the analysis further through interviews with climate scientists themselves. This direct engagement with a cross-section of the principal actors aims to explore the views they hold about their own professional activities as researchers, the ways in which research is funded and executed, and the attitudes and work of scientific colleagues. The present study is thus distinct from, but potentially complementary to a much larger body of research which explores public understanding of science in the specific context of climate change (for example, Hinchliffe, 1996; Drier *et al*, 1999; Dunlap, 1998; for related discussion of the broader theme of the public understanding of science see Irwin, 1995; Irwin and Wynne, 1996; Wynne, 1992, 1993, 1995); and work that focuses on the internal dynamic of debate and exchange within and between the interconnected communities of science and politics as forces shaping the definition of scientific 'truths' (for example, Jasanoff and Wynne, 1997; Shackley and Wynne1995a, 1995b).

A focus on individual experiences also allows the thesis to explore the extent to which scientists present their experiences as a product of particular circumstances, as against assertions of a universal relationship of dependency of scientists on their paymasters advanced in some theoretical accounts. If such differences of experience are seen to exist this might be expected to reflect the specifics of institutional contexts, the academic status and opinions of individual scientists, and the structures of commercial and political decision-making in particular national contexts. The potential importance of such differences has influenced the selection of interview subjects for the present study in ways that are detailed in later chapters. Here, however, attention may be drawn to the logic of the trans-Atlantic element to the thesis. Two of the most important geographical foci of debate about climate change are located in the USA and the UK. Both are home to key centres for climate research and, thus, have significant communities of climate scientists. But the political and diplomatic stance of the two states on climate change policy is rather different. While successive US administrations have resisted commitment to the Kyoto process, the UK remains one of its strongest

supporters. Many of the most prominent business sponsors of the research of climate sceptics are American, while their British counterparts have generally fought shy of such direct involvement in the controversy surrounding climate change science.

1.2 Thesis Outline and Aims

At the heart of the present thesis is an empirical exploration of the practice of climate change science – and specifically of the potential influence of external funding upon its scientific integrity – in relation to wider theoretical debates about the relationship between science and society. This focus also reflects previous studies of climate change science that have called its integrity into question. It is noteworthy, however, that such studies often present only a partial view, with the assertion that it is chiefly researchers on one particular side of the protagonist-sceptic 'divide' who have been unduly influenced by their paymasters, or other external forces, into misrepresenting the scientific evidence. In the thesis that follows an attempt is made to explore the position of both sceptics and protagonists, and the ways that they represent the actions and attitudes of each other.

Chapter Two, however, outlines an initial scientific context in its exploration of the evolution of scientific theories concerning climate change from the early 20th century to current thinking about anthropogenic enhancement of the greenhouse effect. It documents the involvement of key scientific figures and institutional actors in an increasingly politicised debate about the causes and effects of climate change. The chapter also makes a preliminary examination of the increasing attention given by leading developed countries to the funding of climate change.

Chapter Three introduces a theoretical dimension, exploring various attempts to portray the relationships that appear to exist between external economic and political actors and the production of scientific knowledge. After an initial review of alternative perspectives on the science-society relationship, the chapter explores the logic of neo-Marxist thinking as a theoretical foundation for the thesis as a whole. Thinking in this way recognises the potential influence of external forces upon scientific activity, but attempts a more subtle interpretation than the base-superstructure model of some reductionist Marxist models. In particular, a neo-Marxist analysis points to the need to

recognise the diversity of specific interests and functions, both political and economic, that must be disinterred in any examination of the societal base. There is thus a logical basis on which to suggest that individual state agencies and particular economic sectors may pursue quite different agendas in relation to research sponsorship in a field such as climate science. This does indeed seem consistent with what we already know about the different sources of funding available to climate scientists and the particular types of science which individual sponsors seek to encourage. It also reinforces the need to consider the role of scientists and the choices open to them when research funding is potentially available from a range of different sources. In refining the framework for the following empirical chapters in this way, the theoretical material introduced in Chapter Three also adds a further task for the thesis as a whole. Ultimately, it is important that the thesis reflects upon the adequacy of a neo-Marxist analysis as a way of understanding the relationship between climate scientists and their external sponsors.

Chapter Four is concerned with the methodological dimensions of this study. It explores the ways in which the theoretical perspective developed in Chapter Three is used to inform the methodological strategies adopted for this project. Thus, it outlines the development of a schedule of points and questions to be used in semi-structured interviews with climate scientists and scientific commentators, together with a wider rationale for the use of interviews as a means of obtaining empirical information about the practice of UK and US scientists. This is accompanied by discussion of the methods used in identifying specific interviewees, in executing the interviews and in analysing the results. This last in particular involves the comparison and confirmation of information and opinions obtained from interviewees with a range of secondary sources, which are also briefly outlined in Chapter Four.

The empirical study begins in Chapter Five by reviewing evidence of the scale of funding available to support climate change science, focusing on the major concentrations of research activity in the USA and UK. Attention is also given to the main sources of funding, which may offer some indication of its potential distribution in relation to support for the two main 'camps' of sceptics and protagonists. In this way the opening sections of Chapter Five establish a context for a more detailed exploration of scientists' perceptions and presentations of their own activities. The chapter proceeds to review evidence obtained from interviews with scientists and other commentators

regarding their perceptions of the availability of research funding, their awareness of the involvement of different types of funding sources and assessment of the equity with which funding is distributed between scientists in different institutional contexts and between those adopting differing perspectives on questions about the causes and consequences of climate change. In particular, opinion is sought as to whether the distribution (or maldistribution) of funding has implications for the tone and content of scientific debate about climate change – perhaps because it is seen as causing particular viewpoints to be over- or under-represented amongst researchers.

Attitudes towards the availability of research funding are also set against scientists' discussion of the process of securing funding for research. Chapter Five thus also considers accounts of the strategies adopted by scientists – both individually and collectively – as a means of increasing their chances of securing funding. Given the overall aim of the thesis it is important to consider whether any such strategies are presented as compromising scientific independence and integrity. In this respect it is particularly interesting to examine how scientists present their own actions in relation to those of other colleagues. Is there, for example, a tendency amongst interviewees to raise particular questions about the integrity of others with opposing views on climate change? And are any such charges supported by substantiating detail?

The discussion in Chapter Five also raises questions about the relative influence of individual scientists, both within their own community and in affecting external sponsors' judgements about the scale and distribution of funding for climate change research. It is difficult to secure an objective measure of influence to set against the interviewees' accounts. However, one way in which many leading scientists project their influence is through their own publications and the control they exert as referees and journal editors over the publishing record of others. Publications not only shape scientific debate about a particular topic, they are also a tangible expression of scientists' status as experts and thus support their claims on the attention of commercial and political decision-makers. The publishing record of selected figures in the climate debate is therefore reviewed in outline in Chapter Six. The intention here is to consider whether there is any evidence that specific perspectives on climate science have been particularly successful in presenting themselves through the most prestigious and influential scientific outlets, perhaps to the exclusion of dissenting voices. If this is the

case it has implications not only for current scientific debate, but also for the future allocation of much research funding in a context where success in securing funding is often a function of an individual's status as an academic author.

The specific case of research on climate change is related in Chapter Six to wider discussion of the potential for abuse of the refereeing system as a means of marginalising certain voices in academic publishing. Other studies have, however, highlighted the increasing role of alternative forms of publication, particularly on-line, and of the general media, as means of raising the profile of particular scientific perspectives. The use made of such alternative means by various parties in the climate change debate will thus be considered here.

The structure of the empirical enquiry outlined here also reflects the prior examination of existing theoretical discussion of relations between science and society. Neo-Marxist thinking as presented in Chapter Three suggests a series of different rationales which may explain the interest of specific political and commercial agencies in sponsoring research in a field such as climate change. This reinforces suggestions of the importance of efforts to acknowledge the range of different funding sources available to climate change scientists. It also raises questions about the implications of the availability of funding from different sources for different forms of research in relation to questions concerning scientific autonomy. Potentially, at least, diversity in the agendas of particular funding sources creates choices for scientists about how they shape their own research and which sources of funding they pursue. The thesis thus considers whether interviewees recognise the existence of such choices in the present case. However, the introduction of the neo-Marxist theory in Chapter Three does more than influence the content of the subsequent empirical investigation. It also raises questions about the adequacy of this theoretical framework as a means of understanding relations between science and society. The concluding reflections in the final chapter of the thesis thus relate to both the empirical and the theoretical dimensions of the present study.

The specific objectives of the present thesis may thus be summarised as follows:

- to explore the scale and sources of funding available to UK and US climate change scientists;

- to document the accounts of the funding process offered by individual scientists – including their awareness of the availability of funding from different sources and their accounts of the access to funding secured by climate sceptics and protagonists;
- to review scientists' accounts of the influence which funding bodies have upon the practice and content of climate change science, paying attention to potential differences between the activities and the accounts of activities advanced by climate sceptics and protagonists, and by interviewees from the USA and UK;
- to examine scientists' accounts of their activities in relation to the publication of scientific research in both academic and other contexts, and the conclusions drawn concerning the impacts of publication upon decision-making about the funding of further research.

Pursuit of these specific themes is intended to provide the basis on which to address some larger questions about the practice of climate science:

- do scientists themselves share in the perception expressed externally that existing systems of funding compromise the integrity of climate science research?
- do they see any such problems as common to all stances on climate change and all sources of potential funding? – perhaps even to scientific research in general – or as the product of particular circumstances and relationships that can be changed?
- are there strategies which scientists can and do adopt to assert their autonomy? – to what extent do these reflect the influence associated with scientific expertise and/or other circumstances of the funding process in practice?
- do the specific circumstances of academic life in particular national contexts colour scientists' perceptions of their academic roles and freedoms?

The thesis also aims to reflect on the implications of the study of the particular case of climate change science for our wider understanding of the status of scientific knowledge and theoretical discussion of the relationship between science and society.

CHAPTER TWO

Concerns about Anthropogenic Climate Change: Science, Politics and Investment

2.1 Introduction

Scientific concern about the potential for human influence over climate change has been expressed for more than 100 years. However, it was not until the 1970s that national and international scientific and political institutions took a sustained interest (O'Riordan and Jäger, 1996, p.12). This changed the context in which climate research took place, turning an essentially scientific process into one with important political dimensions.

Section 2.2 outlines the science of the natural and anthropogenic greenhouse effect, highlighting the main scientific arguments presented by protagonists. It explores the initial development of the natural climate change theory, pointing out that early interest was centred on glacial cycles and forcing mechanisms. It thus examines the history of the science that led to controversial theories about anthropogenic climate change.

Section 2.3 considers the wider context within which greenhouse theory developed. From the 1950s onwards science became increasingly entwined with politics. This led to a political need for a scientific consensus on the issue because of the mounting concern that climate change represented a threat to social and economic systems. Consequently, a series of international conferences were held in attempt to dispel uncertainty regarding anthropogenic climate change and unite scientists in the discussion of priorities and objectives. This discussion underlines how limitations in understanding the complexities of the issue created opportunities for some scientists to influence the political process, especially within the USA and a lesser extent in the UK. Section 2.3 also shows how scientific uncertainty generated momentum for further research into the area.

Section 2.4 investigates how the climate issue became politicised, outlining the factors that acted to push climate change into the policy arena within the UK and USA.

Section 2.5 attempts to explain the climate debate through a critique of the accounts offered by three key social commentators. All identify similar forces acting within the debate – science, scientists, politics, economic and society - yet they have very different perspectives on the relationships between them.

As a preliminary to subsequent discussion the overall chronology of the unfolding scientific and political processes associated with climate change is outlined is outlined on Table 2.1.

Table 2.1: Chronology of Significant Events: Climate Change

Date	Event
	ERA OF ABSTRACT SCIENCE
1827	▪ Fourier: heat in the atmosphere is analogous to heat in a greenhouse.
1863	▪ Tyndall: CO_2 and water vapour absorb heat affecting temperature and glacial cycles.
1896	▪ Arrhenius: changes in CO_2 levels lead to alterations in the earth's surface temperature.
1899	▪ Chamberlin: CO_2 and water vapour are absorbed by oceans.
1900-1908	▪ Ångström, Koch, Abbot and Fowle: CO_2 and water vapour argued not to absorb as much heat as previously thought. Global warming theory, therefore, lies dormant until 1930s.
	SCIENTIFIC ADVANCES
1930s	▪ Callender: re-establishes the importance of CO_2 to climate change. Recognises that anthropogenic changes, as well as natural variation, can alter climate.
1957	▪ Revelle and Suess: CO_2 not absorbed by oceans to extent previously presumed, suggesting rise in CO_2 levels in atmosphere. ▪ International Geophysical Year: 30,000 international scientists discuss ideas and complexities of atmosphere – attempt to establish scientific consensus. ▪ IMO established: attempts to institutionalise cooperation ▪ Mauna Loa Observatory established to monitor CO_2 concentrations.
	ERA OF POLITICISATION
1963	▪ Conservation Foundation report: first report by NGO on climate change – stimulates political reaction.
1965	▪ PSAC report: public recognition that human activities could cause climate change.
1968	▪ World Weather Watch established: attempts to extend and expand international cooperation in collection and distribution of weather data.
1970	▪ SCEP: raises awareness of anthropogenic climate change.
1971	▪ SMIC: continuing focus on raising awareness of anthropogenic climate change, but no consensus reached. Key advisory paper to UNCHE.
1972	▪ UNCHE: emphasises seriousness of climate change to international political community.
1975	▪ NAS report: highlights need for further climate research.
1977	▪ NAS report: calls for further research – combined with 'prompt action' to address climate change.

Table 2.1: Chronology of Significant Events: Climate Change (continued)

1979	▪ First World Climate Conference: recognises need for greater international cooperation and advancement in 'scope and complexity' of climate science. ▪ World Climate Programme created by WMO. ▪ NAS report: emphasises credibility and scientific basis of climate models.
1980	▪ Villach Conference: rising levels of greenhouse gases will negatively effect the earth's equilibrium.
1981	▪ Hansen: sends pre-print reports to *New York Times* to raise profile of issue.
1985	▪ Villach Conference: alliance between scientists and politicians – global warming placed on the political agenda. ▪ AGGG established: investigates policy actions to reduce greenhouse gases.
1987	▪ Villach-Bellagio workshops: call for 'agreement on a law of the atmosphere as a global commons or the need to move towards a [climate] convention' (Paterson, 1996a, p.31). ▪ UNEP and WMO: agree to establish intergovernmental body to assess climate science and formulate responses.
INTERNATIONAL GOVERNMENTAL TAKEUP OF ISSUE	
1988	▪ Hansen: speaks to US Senate claiming that the 'greenhouse effect is here'. ▪ Toronto Conference: recognises political urgency of action to reduce CO_2. ▪ World Atmosphere Fund established: funded by levy on fossil fuels companies – recognised as major contributors to CO_2 emissions. ▪ IPCC established: aims to establish scientific consensus and gain greater political interest in climate change. ▪ Thatcher and Bush senior: recognise the importance of the issue.
1989	▪ Formation of Special Committee on the Participation of Developing Countries: aims to represent developing countries in IPCC ▪ AOSIS established: global warming now seen to be truly international. Emphasises concern for low-lying developing countries. ▪ CAN established: NGOs group together to lobby for emission reduction policies.
1990	▪ Second World Climate Conference: backed by WGI of IPCC. Leads to international political concern and recognition of need for climate convention. Recognises potential impact of anthropogenic climate change on ecosystems. ▪ IPCC First Assessment Report: raises prospect of huge stress on natural and social ecosystems if greenhouse gases are not reduced.
1992	▪ Rio Earth Summit (UNCED): FCCC opened for signatories - countries to commit to reducing greenhouse gas emissions - no legally binding targets. Recognises uncertainty not to be used as an excuse for delaying emission reduction implementation.
1996	▪ IPCC Second Assessment Report: Asserts that ' balance of evidence suggests that there is a discernible human influence on global climate' (Houghton *et al*, 1996, p.5).
1997	▪ Kyoto Protocol: specific limits on greenhouse gas emissions but no penalties if unenforced. 160 states, parties to FCCC, adopt Kyoto Protocol. ▪ Uncertainty still being used by some governments as excuse for inaction.
2000	▪ Hague meeting of Kyoto parties: no agreement on implementation of Protocol. ▪ EU and US: disagree over terms for achieving greenhouse gas emission reduction policies.
2001	▪ IPCC Third Assessment Report: claims CO_2 emissions are rising – as a consequence of human activities. ▪ NAS report: supports IPCC findings. ▪ Meeting of Kyoto parties: Protocol signed – without USA.
2002	▪ Kyoto Protocol now signed by 84 Parties and ratified by 74.

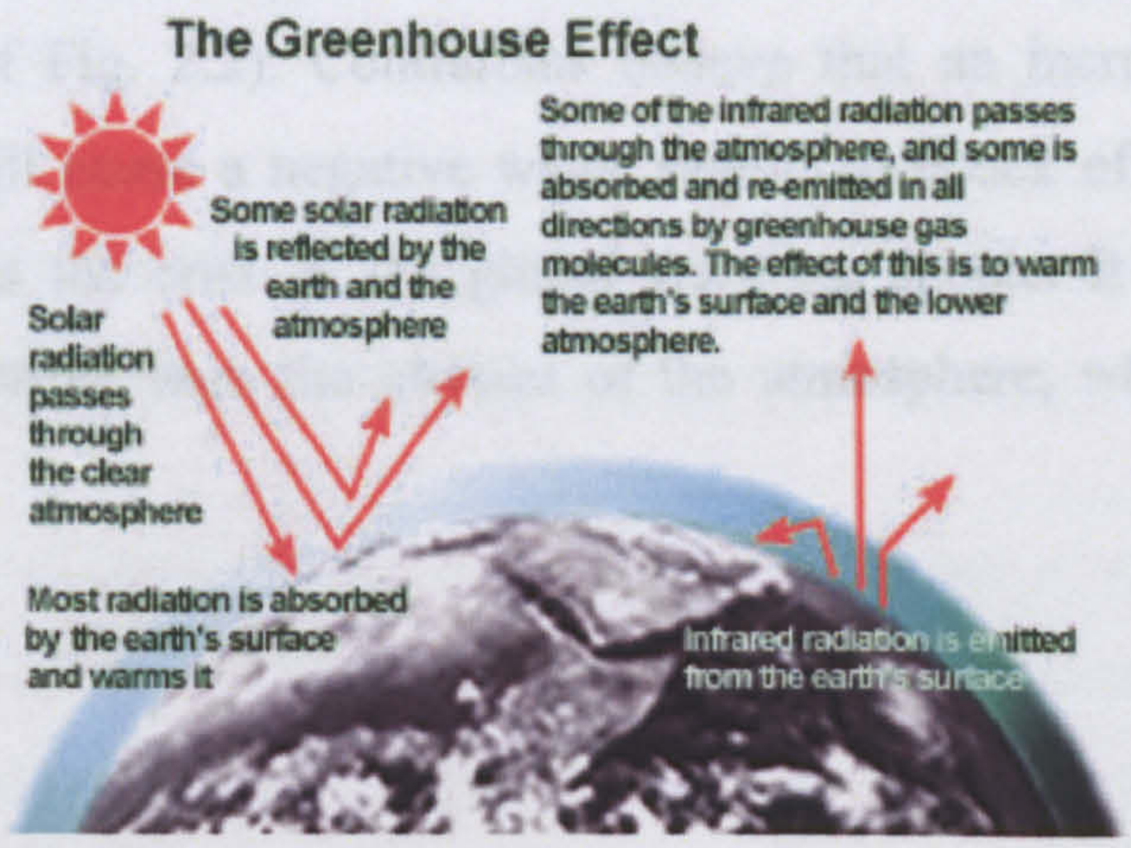
2.2 The Science of the Greenhouse Effect

2.2.1 The Natural Greenhouse Effect

The greenhouse effect is a naturally occurring process which drives the climate. The basic understanding of the workings of the climate-atmosphere system is not disputed among scientists (Houghton *et al*, 1996; Houghton *et al*, 2001). To understand these mechanisms an energy balance model can be used.

The earth–atmosphere system must achieve a thermal equilibrium of radiant energy to preserve a constant temperature at the surface and the top of the atmosphere (TOA). The energy balance is different at these two locations. At the TOA seventy units of short-wave radiation pass through the upper atmosphere, which has to be balanced by 70 units of long wave radiation going out. At the earth's surface 51 units of short wave radiation from the sun are absorbed and 51 units of long wave radiation are radiated into the atmosphere. Greenhouse gases: water vapour, carbon dioxide and methane absorb this long wave radiation, predominantly in the troposphere. These gases scatter this radiation in all directions, downward to the surface of the earth and upward to the stratosphere (see Fig. 2.1). This is known as radiative forcing. The gases 'act as a partial blanket' enabling the earth to be 33°C warmer than it would otherwise be without them (Drake, 2000, p.24; see also Houghton *et al,* 1996; Houghton, 1997). This is the naturally occurring greenhouse effect, which raises the annual global average temperature of the earth's surface to about 15°C.

Figure 2.1: The Natural Greenhouse Effect.



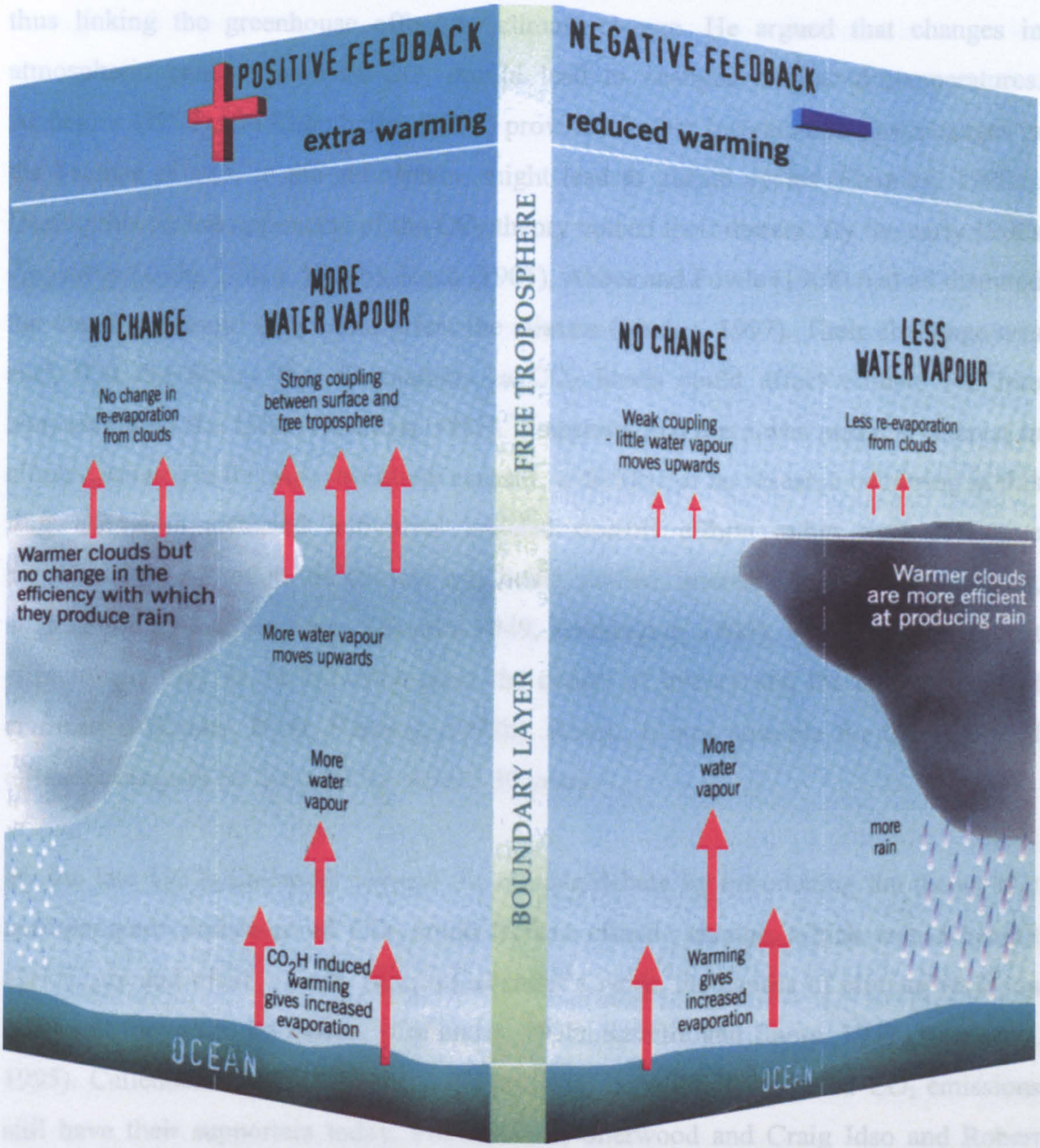
(Source: Environmental Protection Agency, 1999)

2.2.2 The Anthropogenic Greenhouse Effect

Human activities, such as the combustion of fossil fuels, deforestation and biomass burning, can increase the concentration of greenhouse gases in the atmosphere. This increase in concentration of greenhouse gases alters the radiative forcing and has the potential to lead to anthropogenic climatic change. At the earth's surface an increase in long wave radiation from the atmosphere (mainly the troposphere) occurs. The surface responds by heating up to balance the radiant energy it is receiving. As the troposphere is emitting more radiation downwards it also emits more radiation upward towards the stratosphere. As the stratosphere is receiving extra radiation it cools to maintain equilibrium. Thus, there is a change in temperature structure throughout the atmosphere, to a new surface equilibrium. This is known as the human-induced or anthropogenic greenhouse effect.

Hypothetically, increasing the concentration of CO_2 and other greenhouse gases, without triggering a response from the earth-atmosphere system (i.e. with no internal feedback) would only raise surface temperatures by 1°C (Houghton *et al*, 1990). The likelihood is, however, that the earth-atmosphere system will respond to the increased concentration of greenhouse gases through feedbacks, either positive or negative, within the system. Protagonists predict a vigorous positive feedback. As the earth warms the amount of water vapour in the upper (free) troposphere increases. As water vapour is a greenhouse gas it amplifies the warming. It is believed by protagonists that this will lead to global warming and major climate shifts (Houghton *et al*, 1996, p.58). Increases in cloud may act either to amplify the warming (a positive water vapour feedback effect, see left-hand-side of Fig. 2.2), or reduce it (negative water vapour feedback effect, see right-hand-side of Fig. 2.2). Contrarians believe that an increase in greenhouse gas concentrations will cause a negative water vapour feedback effect. This water vapour feedback effect is the crux of the global warming debate. It is the response of the climate system, rather than the physics of the atmosphere, which is disputed among scientists.

Figure 2.2: Water Vapour Feedback Mechanisms



(Source: Pearce, 1997, p.41)

2.2.3 Early Key Developments in Climate Science: the Development of the Greenhouse Theory

The development of the greenhouse theory can be traced to the early 1800s and the work of Fourier (1827) (see Table 2.1) (Agrawala, 1998a; Drake, 2000; Christiansen, 1999; Mudge, 1997). Climate science was fragmented during the 19th century and the issue attracted the attention of only a few scientists. With the gradual acceptance of the existence of quaternary glacial cycles, climatologists began to look for mechanisms

capable of promoting such climate changes. Whilst Fourier had proposed the natural greenhouse effect, it was Tyndall (1863) who developed the theory to address ice ages, thus linking the greenhouse effect to climate change. He argued that changes in atmospheric concentration of CO_2 would lead to changes in glacial temperatures. Arrhenius (1896) and Chamberlin (1899) provided further insights into how changes in the balance of CO_2 in the atmosphere might lead to glacial cycles (Fleming, 1998a). During this period opponents of the CO_2 theory voiced their dissent. By the early 1900s Ångström (1900, 1901a, 1901b), Koch (1901), Abbot and Fowle (1908) had all disputed the idea that natural CO_2 could affect the climate (Mudge, 1997). Their challenge was such that the theory that fluctuations in CO_2 levels could affect climate fell into abeyance until the 1930s (Kellogg, 1987). It appears that there was minimal interest in climate science in the early twentieth century, with little or no research occurring in this area. Research reflected individual isolated one-off efforts rather than collective contributions. Although the climate was being studied, interest concerned other areas, such as climate determinism (Brooks 1949; Huntington 1907), which suggested that climate was very as an influence upon the course of history and the development of civilisation (Drake, 2000; Fleming, 1998b). Hence, it was possible for the theory of climate change to lie dormant for around 30 years.

By the late 1930s Callender revived the climate debate by introducing the theory that anthropogenic emissions of CO_2 could lead to climate change, which would benefit agriculture and plant growth. Before Callender's work, the causes of climate variation had been though to be natural (Callender, 1938; Revelle and Suess, 1957; Rowlands, 1995). Callender's arguments about the potential benefits of increased CO_2 emissions still have their supporters today. For instance, Sherwood and Craig Idso and Robert Balling (2000) suggest that an increase in atmospheric CO_2 would act as an effective aerial fertiliser and enhance the growth of vegetation (Idso *et al*, 2000; see also Morris, 1997). Callender also thought that warming from human activities would protect humanity against an ice age (Callender, 1938). His ideas were radical and contrary to the general scientific consensus of the time. However, the scientific community was not that interested in his research, never mind the public or politicians. Thus, he encountered widespread scepticism. Coste (1938), Brunt (1938) and Brooks (1938) argued that an increase in CO_2 from human emissions could not affect climate because of the absorbing quality of oceans. This effectively ended discussions of Callender's theory until the late 1950s (Callender, 1938).

By the early 1940s, however, terrestrial data (thermometers) revealed an increase in average surface temperature compared to early decadal readings; decreases in Arctic ice and rises in sea levels were also recorded. Scientists were reluctant to acknowledge that this was perhaps a result of an increase in anthropogenic CO_2, rather than being due to natural forcings. The possibility that humanity could influence the 'vast scale' of the climate was incomprehensible at this time. Many asked 'how can little creatures like us compete with those titanic forces that drive the winds of the atmosphere and the ocean currents' (Kellogg, 1987, p.113). Climate research still reflected a continuing interest in scientific observation by a small community of scientists.

2.2.4 Recent Key Developments in Climate Science: a Growing Consensus of Scientists Supporting the Greenhouse Paradigm

In the late 1950s climate science began to involve a larger community of researchers. Interest in climate change escalated and there was greater openness to theories. At this time Roger Revelle, a well-respected oceanographer, appears to have been an influential individual who inspired new interest in climate science. In particular, he challenged the general scepticism regarding Callender's theory of anthropogenic climate change (Hart & Victor, 1993). In research funded by the Scripps Institute of Oceanography, Revelle and Suess, claimed that the oceans did not absorb as much CO_2 as formerly thought, thus 'most of the CO_2 added by fossil fuel combustion…has gone into the biosphere' (Revelle and Suess, 1957, p.24). They estimated, therefore, that atmospheric CO_2 concentrations would rise by between 20-40 per cent in the following decades, given present trends in energy consumption in advanced industrial countries. They claimed:

> Human beings are now carrying out a large geophysical experiment of a kind that could not have happened in the past, nor be reproduced in the future (Revelle and Suess, 1957, p.19).

Revelle's research provoked interest and concern about climate change, which led to the International Geophysical Year (IGY), a UN-sponsored international programme to learn about the earth's physical systems, between 1957–1958 (Miller and Edwards, 2001, p.46; Rowlands 1995). Revelle and Suess's research appeared to have caused excitement and interest in understanding the complexities of weather and climate processes. The IGY brought together 30,000 scientists to share ideas and begin to create

a general consensus on climate change (Paterson, 1996a, p.22). It was also the first meeting that internationalised the subject (or at least interest and debate began to be more widely evident throughout the developed world). Hence the IGY was jointly sponsored by the WMO and the International Council for Scientific Unions (ICSU). To test Revelle and Suess's theory it was necessary to establish regular measurements of atmospheric CO_2. Consequently, Mauna Loa Observatory set up the first reliable and continuous data set of background CO_2 concentrations, which is still active today (Kellogg, 1987, p.117; Woodwell, 1978, p.34). The success of the IGY led to greater interest and international co-operation in meteorology (Soroos, 1991). In the 1960s much of the science of global climate change was still unexplored, there were only a few scientists who were concentrating on climate fluctuations. However, Revelle and Suess's research had led to substantial developments in climate science highlighting the influence of key scientists upon the direction of research (Hart & Victor, 1993; Rowlands, 1995). By the late 1960s the anthropogenic greenhouse paradigm became increasingly accepted within the international scientific community. The World Weather Watch was established by the WMO and ICSU, in 1968, to extend and expand co-operation between countries by collecting and distributing weather information. Thus, larger scale research on climate change was beginning, which eventually contributed to generating a significant measure of agreement on the subject.

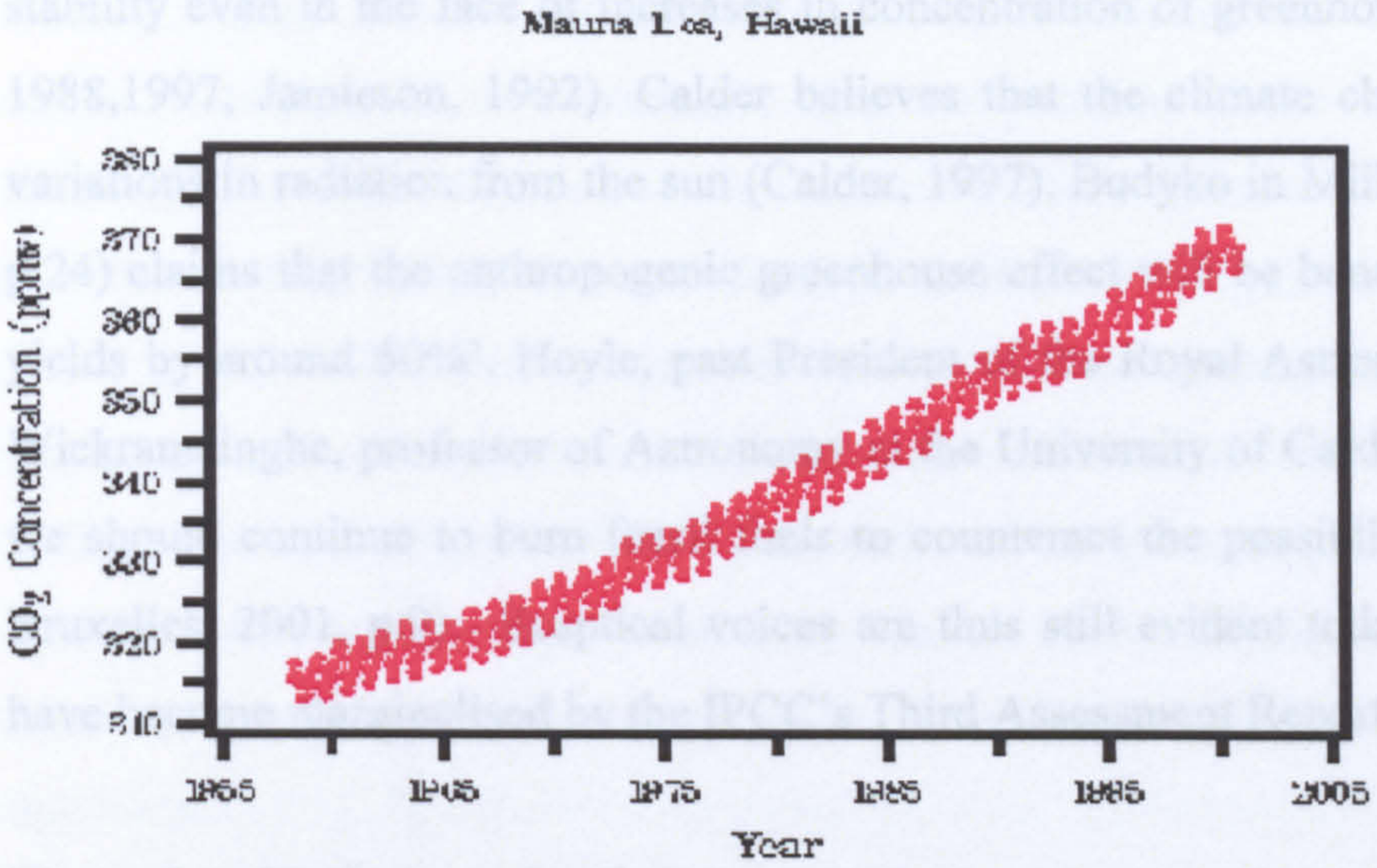
In the 1970s Flohn and Mitchell highlighted a drop in air temperatures that had been occurring since the 1940s (Flohn, 1977, p.4; Lamb, 1972, p.613; Mitchell, 1972, p.441). Consequently, a new debate was ignited regarding the significance of this present trend in climate, which was related to the effect of industrial aerosols and general climate variability (Agrawala, 1998a, p.607). Some speculated that it was the onset of the next ice age (Kellogg, 1979; Ponte, 1976; Schneider, 1976). During the course of these discussions Rasool and Schneider put forward the idea that anthropogenic emissions of CO_2 and aerosols were more 'likely to lead to a reduction rather than an increase in global temperature' (Rasool and Schneider, 1971, p.17 and p.224). (Schneider has since reconsidered his view on climate change and now firmly believes in global warming). Thus, the climate change theory appeared to be loosing scientific support at this time. Bert Bolin, the new director of the World Meteorological Organisation, was, however, promoting his pet theory, of Global Warming. This perhaps contributed to the rejection of Rasool and Schneider's hypothesis by the scientific community and growing belief in anthropogenic climate change. Yet, one important by-product of Rasool and

Schneider's work was the recognition of aerosols as significant particles in the atmosphere. Their incorporation in global climate models has allowed modellers to reproduce observed climate trends (see Houghton *et al,* 2001). As a result, by the late 1970s the ice age theory had been dismissed, resulting in a stronger scientific consensus on global warming. The growing sophistication of climate modelling during the 1970s provided further support for anthropogenic climate change. One of three reports by NAS (1979) highlighted the credibility and scientific basis of climate models. Kellogg claims that with models backing climate scientists it was increasingly difficult to doubt that a doubling of CO_2 concentrations would lead to warming (Kellogg, 1987, p.116). A critical mass of scientists now believed that global warming was possible and serious. This both reflected and reinforced the extension of climate science as a focus for large-scale research, often including international collaboration (Paterson, 1996a).

By the mid 1980s, data were available to show that the rise in CO_2 was not only attributable to fossil fuel combustion, but also to deforestation. In addition, CFCs, methane, nitrous oxides, and tropospheric ozone were recognised as being 'radiatively important'; in other words, they also contributed to the anthropogenic greenhouse effect (Malone, 1986, p.30). This led to greater concern among the scientific community about the potential seriousness and effect of climate change. With developments in the scope and complexity of General Circulation Models (GCMs) the external profile of global warming rose, further supporting climate scientists' theories.

Outside interest regarding the scale of the potential damage that climate change could inflict, and a critical mass of scientific support for global warming meant that a public consensus on the issue had to be established. In the late 1980s, therefore, the Intergovernmental Panel on Climate Change (IPCC) was established. This collated climate research and generated even further interest in the issue, both inside and outside the scientific community. Through the IPCC stronger statements about the effect of anthropogenic climate change emerged. For example, in 1990 the scientific working group of the IPCC (WGI) stated that tropospheric CO_2 was calculated to have increased by 31%, from 280 ppmv in 1750 to a value of over 360 ppmv by 1997 as a result of industrialisation, mainly due to the combustion of fossil fuels and deforestation (See Fig. 2.3) (Houghton *et al,* 1990). Thus, they argued for an immediate reduction in CO_2 emissions by 60% to stop the build-up.

Figure 2.3: The increase in atmospheric CO_2 concentration since 1957



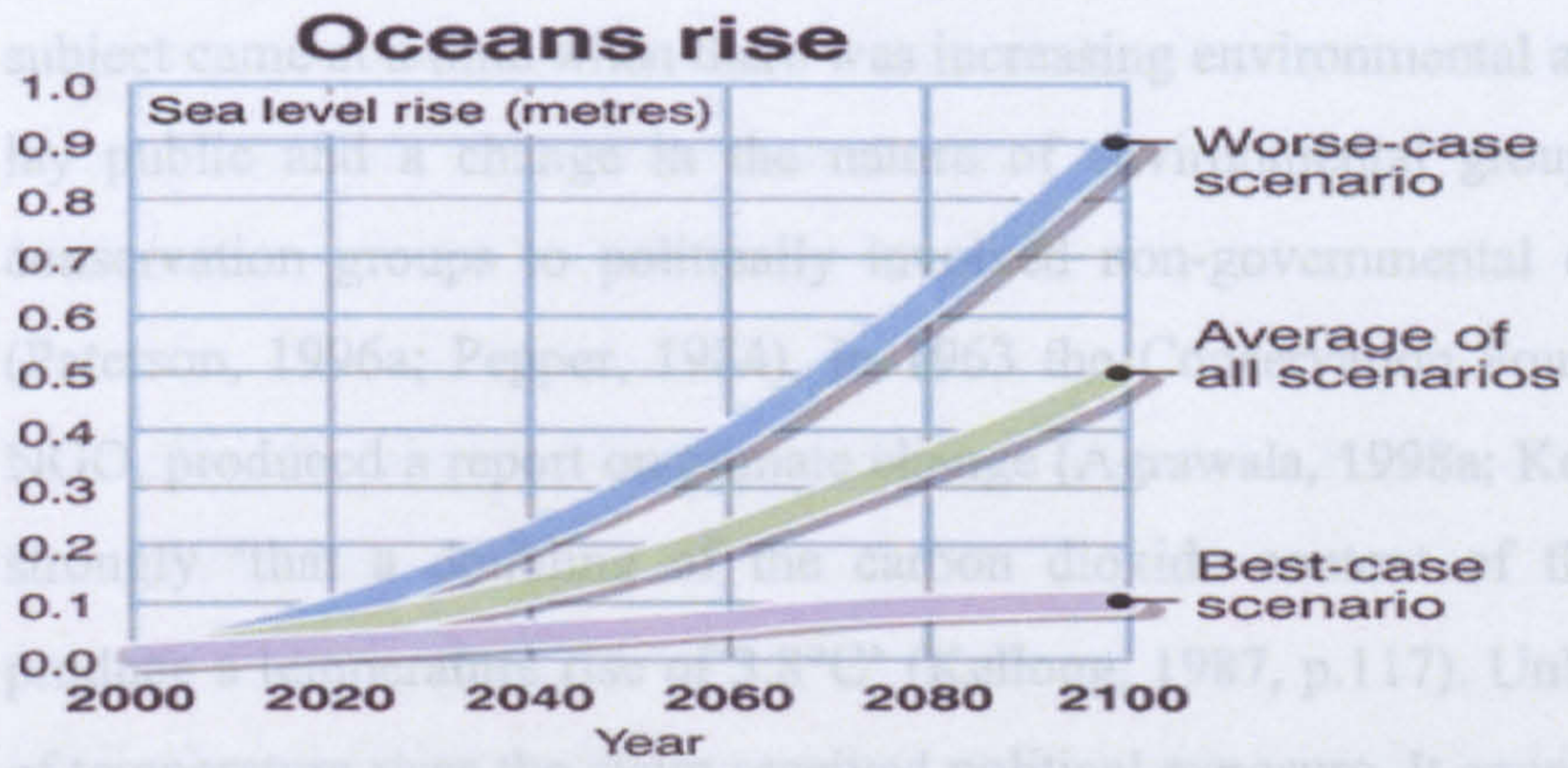
(Source: Keeling and Whorf, 1998)

Support from the scientific community continued to grow for theories of global warming throughout the 1990s. Scientists who supported the IPCC believed that the surface of the earth could warm by 6°C within a century (Houghton *et al*, 2001). This would increase the risk of extreme climate events, threaten unique ecosystems, continue to erode northern snow cover and sea-ice, cause additional retraction of glaciers and ice caps and further increases in sea level (see Fig 2.4) (Houghton *et al,* 2001). With greater certainty and a stronger consensus within the scientific community, dissenters on the issue became more visible and vocal in their challenge to the 'accepted paradigm'. This was not a wholly new phenomenon, rather these viewpoints started to matter more as the debate became increasingly politicised (see section 2.2.3).

These dissenting voices included the well-respected US professor, Richard Lindzen, who believes that water vapour 'would compete with, not reinforce, global warming caused by CO_2' causing a negative feedback (Lindzen quoted in Pearce, 1997, p.41; see also Lindzen, 1994; Lindzen *et al*, 2001; Schneider *et al*, 1999; Sun *et al*, 2001). Such thinking still retains a degree of credibility. Another American, Patrick Michaels also argues that the climate is less sensitive than the mainstream thinking on climate change accepts and that the observed warming is in fact a natural temperature trend (Michaels quoted in Pearce, 1997; Michaels and Knappenberger, 1996; Michaels (1991a; 1993; 1994). Contrarians, including Nierenberg (1993; 1995) and Singer (1992; 1998; 2001), highlight the inability of climate models (GCMs) accurately to represent the atmosphere

system. Lovelock suggests that the Earth is self-regulating and preserves climate stability even in the face of increases in concentration of greenhouse gases (Lovelock, 1988,1997; Jamieson, 1992). Calder believes that the climate changes as a result of variations in radiation from the sun (Calder, 1997). Budyko in Miller and Pearce (1989, p.24) claims that the anthropogenic greenhouse effect will be beneficial 'raising [crop] yields by around 50%'. Hoyle, past President of the Royal Astronomical Society, and Wickramainghe, professor of Astronomy at the University of Cardiff, even suggest that we should continue to burn fossil fuels to counteract the possibility of an ice age (de Bruxelles, 2001, p.9). Sceptical voices are thus still evident today, even though they have become marginalised by the IPCC's Third Assessment Report.

Figure 2.4: Various sea level rises scenarios



(Source: EPA, 2001)

2.3 The Politicisation of Climate Science

2.3.1 The Politicising of Climate Science: The Precursor to the Direct Involvement of Politicians in the Debate

Today, climate science is increasingly entwined with politics, reinforcing the position of scientists as potentially influential knowledge holders in the debate (Haas, 1992). The politicisation of climate change can be traced to the 1950s. The subsequent efforts of certain key or elite scientific figures, backed by the weight of the scientific community are seen to have succeeded in placing the issue firmly on the political agenda by the 1980s (Hart and Victor, 1993; Paterson, 1996a). As Mulkay (1976) notes, the scientific elite are potentially influential figures as they are well-established and have a network

of social relations. Between the 1950s and 1970s the importance of anthropogenic climate change became recognised within both national and international political realms. However, the chief scientific input and political debate was centred in the US. Miller (2001) argues that America's interest in climate science during the post-war era was 'intertwined with the pursuit of a free, stable, and prosperous world order' (Miller, 2001, p.173). The IGY began the process of connecting scientists of different disciplines and nationalities into networks for collaboration and the exchange of ideas (O'Riordan and Jäger, 1996). This reflected a general perception that without international co-operation, research could not advance. The International Meteorological Organisation (IMO) was, therefore, established to institutionalise co-operation.

The gradual development of a critical mass of international scientific support for the subject came at a time when there was increasing environmental awareness amongst the lay public and a change in the nature of environmental groups from non-political conservation groups to politically involved non-governmental organisations (NGOs) (Paterson, 1996a; Pepper, 1984). In 1963 the Conservation Foundation, an American NGO, produced a report on climate change (Agrawala, 1998a; Kellogg, 1987). It stated strongly 'that a doubling of the carbon dioxide content of the atmosphere would produce a temperature rise of 3.8°C' (Kellogg, 1987, p.117). Unlike earlier predictions of temperature rises the claim received political exposure. It appears that as early as the 1960s pro-environmental NGOs reached a critical turning point, taking advantage of the increase in public concern for the environment. Recognising the potential political influence and seriousness of global warming, NGOs adopted climate change as a campaign issue (See section 2.4.2). The change in NGOs' strategies and their subsequent influence upon the political system caused a reaction from the US President's Science Advisory Committee (PSAC). Commissioned by the US government, with the aim of restoring 'the quality of our environment', the PSAC's involvement gave public recognition to claims that climate change could be caused by human activities and would have important consequences for the world (Kwa, 2001, p.156, see also Agrawala, 1998a; Kellogg, 1987; Rowlands, 1995). The PSAC statement was probably as strong as it could have been at the time, emphasising marked changes for the environment and humanity. Scientists were unable to commit themselves fully to strong conclusions due to the lack of hard evidence at this time (Rowlands, 1995).

As noted earlier, Revelle appears to have been a 'concerned' scientist who, at an early stage in the climate debate, was seen to engage willingly in politics and propel the issue onto the wider political agenda. He appears to be one of the first climate scientists who ceased to be purely a scientist, crossing the line between science and politics. Indeed, he was heavily involved in the IGY and he chaired the sub-panel of the PSAC. He also recognised the need to establish a weight of scientific support behind climate concerns and for collective research to help advance the subject on the political stage (Paterson, 1996a; Hart and Victor, 1993). This emphasises his determination to establish climate change on the political agenda and gain political support for action to combat global warming. It also highlights the opportunism of an individual scientist (See Section 2.5) (Hart and Victor, 1993). Revelle's influence, coupled with other perhaps stronger pressures, such as the publication of Silent Spring (Carson, 1962), a radical publication criticising the chemical industry's impact upon nature, and the general weight of scientific opinion, forced politicians to think seriously about the environment (Burnside, 2002, p.1).

2.3.2 The Development of Scientists Involved in Politics: Some Scientists Stop Being Scientists

US Professor William Wilson can be credited with further establishing climate change on the political agenda, as well as securing an obvious critical mass of scientific opinion in support of the theory of anthropogenic climate change in the early 1970s (Hart and Victor, 1993; Paterson, 1996a). Organised by Wilson, the Study of Critical Environmental Problems (SCEP) of 1970 - sponsored by the Massachusetts Institute of Technology (MIT) and a variety of governmental organisations, private foundations, and corporations - directly aimed to raise 'the level of informed public and scientific discussion and action on global environmental problems' (Kellogg, 1987, p.120). SCEP brought together a distinguished committee of over 70 American scientists thus securing the weight of scientific opinion needed to push climate change onto the political agenda (see section 2.5).

The subsequent Study of Man's Impact on Climate (SMIC), organised by Wilson in 1971, and involving the international scientific community, was intended to further the 'process of co-operation among the nations of the world [by trying to] provide an

international scientific consensus on what we know' (SMIC, 1971, p.12). SMIC was not as successful as had been hoped; a consensus among scientists was not established because there were 'just too many honest differences of opinion and not enough hard facts at hand to resolve them' (Kellogg, 1987, p.121). There was also a reluctance to 'stick out one's neck' (*Ibid.*). However, SCEP and SMIC had raised awareness of the greenhouse issue among political institutions. The reports emphasised the importance of CO_2, which led to the inclusion of climate change on international institutions' environmental agendas (Kellogg, 1987). Furthermore, it highlighted that there was a legitimate debate. SMIC was also a key advisory paper to the UN Conference on the Human Environment (UNCHE) in 1972, helping to alert the international political community to the seriousness of climate change.

2.3.3 Growing International Political Awareness and Concern: Key Scientists Establish Political Support

Belief in theories of anthropogenic climate change was beginning to gain stronger ground within the scientific community and given greater priority among political agendas during the 1970s. Scientists, politicians, businesses and the public took greater interest in the issue. This was compounded by the severe global weather events of the 1960s and 1970s, which further raised concern about the possible consequences of anthropogenic climate change upon humanity (See section 2.4.3) (Christiansen, 1999, p.197; Paterson, 1996a, p.25; Rowlands, 1995, p.68). An analysis of the number of international conferences held during the 1960s and 1970s indicates an increased interest in and concern about greenhouse science. For instance, between 1971 and 1979, excluding United Nations' meetings, there were more than 15 international conferences on the topic of climate change. The United States still appears to have been driving climate change research during this period. Indeed, there were far more scientists researching climate change in the USA than anywhere else in the world. Of the 15 international conferences, reports and meetings, the US organised just under half. The others were collective international efforts rather than the result of initiatives taken by individual national institutions. Furthermore, a series of US government funded NAS reports (1975; 1977; 1979) were some of the first major government studies to investigate the causes and consequences of climate change (Hart and Victor, 1993). These reports also emphasised both the need for further research into greenhouse

science and the importance of 'prompt action' to curb climate change, even while uncertainty about its cause and extent still prevailed (Rowlands, 1995, pp.69-70).

Contradiction, debate and uncertainty characterised climate science, which is still evident today. The increasing recognition of the importance of climate change during the early 1970s was further stimulated by reports of possible benefits on the one hand, (see for example, National Research Council, Committee on Atmospheric Science, 1973) and potentially serious consequences, on the other. However, debate during the 1970s echoed uncertainties over the verifiability and consequences of climate science. There were also few definite statements about the scale of potential climatic changes. Kellogg implies that this silence from the majority of the scientific community reflected an unwillingness or inability to commit to uncertain science. Indeed, scientists are trained not to jump to conclusions. Scientists were also aware of the inability of science at the time to interpret the complexities of the climate system (Kellogg, 1987, p.122). However, the World Climate Conference in 1979 led to greater understanding of climate change and also emphasised the need for greater international cooperation. It highlighted a need for advancement in the 'scope and complexity' of climate science, and called on all nations to unite in efforts to understand climate change, to plan for it, and where possible to lessen its effects (Kellogg, 1987, p.124). Research had begun to gather enough interest and scientific understanding to initiate debate concerning the potential consequences of climate change. International bodies were set up and conferences began to discuss the implications for society at large.

Paterson suggests that it was institutional, technical and organisational developments within the WMO and the ICSU that helped to co-ordinate and achieve greater agreement in climate science (Paterson, 1996a, pp.23-25). There was a definite rise in international interest in anthropogenic climate change in the 1970s. Yet the existence of the debate, drawing in other actors (particularly big business) created new sources of controversy and uncertainty. Corporate interests in the UK and US began to support scholars whose views were compatible with their own outlook and approach to stringent emission reduction policies which might impose economic burden. Thus, the direct sponsorship of sceptical scientists began. This provided new opportunities for scientists such as Seitz and Singer to advance their stance through anti-environmental NGOs (Beder, 1999; 1997).

2.3.4 The New Phase: A New International Arena for Climate Debate

Key US scientists, such as Hansen, who was director of NASA's Goddard Institute for space studies, and Schneider, Hansen's co-researcher – who now believed in global warming – took a leading role in stimulating a rise in public interest in climate change in the 1980s (Christiansen, 1999). In 1981, Hansen attempted to raise the profile of the issue by sending a pre-print report, which argued that the present warming trend was linked to anthropogenic climate change, to the *New York Times* (Mazur and Lee, 1993, p.694). It appears that he was aware of the potential impact of the research. The majority of scientists were becoming more convinced that the anthropogenic greenhouse effect was responsible for the warming experienced during the 1980s, therefore adding to the weight and subsequent influence of scientific opinion (Paterson, 1996a). The issue was also advanced by international journals such as *Science* (see for example, Hansen, 1981). The publication of articles in leading journals suggesting that climate change would cause critical human impacts was a further stimulus to scientific and political interest in the topic (Woodwell, 1987). Prominent individual scientists were, therefore, supported by a critical mass of their colleagues who were simultaneously pushing the issue, providing weight behind the protagonist perspective on climate change (Hart & Victor, 1993; Paterson, 1996a).

The well-publicised speech by Hansen, to the US Senate in the summer of 1988 persuaded politicians to consider the threat of anthropogenic climate change more seriously. Not least because Hansen was emphatic that 'the greenhouse effect is here', pronouncing a '99 per cent' certainty that the recent warm weather was a result of climate change (Christiansen, 1999, p.196, see also Hare, 1988). It was no coincidence that Hansen's speech was scheduled for the hottest day in the year in Washington D.C., at a time when there was also a serious national drought, the worst since the 1930s. Thus, the hearing attracted the mass media, drawn by the prospect that an important statement relating to the drought would be made by Hansen (Mazur and Lee, 1993, p.697). Mazur and Lee claim that the meeting had been deliberately scheduled for the warmest period in the year to gain greater media coverage. Indeed, the American public were growing increasingly restless because of the severe drought affecting 40% of the country (Christiansen, 1999). The following day reporters claimed that global warming was occurring. The *New York Times* published a front-page article which stated that 'the earth had been warmer in the first five months of this year then in any comparable

period since measurements began 130 years ago' (Shabecoff, 1988). Hansen's networking among the mass media and politicians, prior to his high profile presentation, contributed substantially to the impact of his speech and the take-up of the issue. One month prior to Hansen's hearings the *New York Times* published several articles linking the drought to global warming (See for example, *New York Times*, 14th June 1988; 17th June 1988; 22nd June 1988; 23rd June 1988). Furthermore, because Hansen had previously given low-key presentations and was generally regarded as being a cautious scientist – 'a proponent of the "wait and see" approach' – his statement was especially influential (Gribbin, 1990a, pp.3-4). Today Schneider, is also a prominent and vocal protagonist both in the UK and USA. However, in the late 1980s Schneider initially played down Hansen's testimony, possibly because he was uncertain about the science at that time (Schneider, 1988).

With a growing mass of support, the Villach conference (1985) was convened by the World Climate Programme and the WMO (Agrawala, 1998a; Kellogg, 1987; Rowlands, 1995). Villach fostered an alliance between key members of scientific and political establishments, which led to the issue being placed more securely on the political agenda, especially in USA and UK. The conference emphasised the need to move away from a stress on further research and towards political action. Specific economic, social and technological research measures to deal with the issue were advanced (Paterson, 1996a, pp.30-31). The ultimate outcome of Villach was to strengthen the resolve to secure political action against climate change. For example, an Advisory Group on Greenhouse Gases (AGGG) was established to investigate policy actions to reduce greenhouse gases (Agrawala, 1998a, p.609).

The Toronto Conference (1988) entitled 'The Changing Atmosphere: Implications for Global Security', sponsored by the Canadian government, with support from the UN and the WMO, was the next important international conference (Global Climate Change Digest, 1988). It emphasised political urgency, pointing to the need for governments and industry to reduce CO_2 emissions. It also established the World Atmosphere Fund financed by a levy on fossil fuel consumption in industrialised countries. For the first time the fossil fuel industry was pinpointed as a major contributor to the climate problem. Thus there were increasing calls for its active participation in reducing the potential affects of climate change. Against a backdrop of environmental concern, political and scientific support for action on climate change seemed strong. World

leaders were, therefore, forced into action as they could no longer ignore the issue. Margaret Thatcher, then the British Prime Minister, stated, in words that echoed Revelle's speech in 1956, that humankind had 'unwittingly begun a massive experiment with the system of the planet itself' (Thatcher, 1988, quoted in Paterson, 1996a, p.34). Thatcher's adoption of the issue reflected not only the general scientific belief in the reality of climate change but also the influence of key individuals, both scientists and non-scientists (Hart and Victor, 1993; Paterson, 1996a). For instance, Sir Crispin Tickell, then the UK Ambassador to the United Nations, and author of *Climatic Change and World Affairs* (1977) helped to convince her of the significance of anthropogenic climate change and the urgent need for restorative action. James Hansen also influenced her through a number of presentations (McCormick, 1991, p.63). Furthermore, George Bush Senior focused on climate change in his presidential election campaign in 1988. He pledged his support for action on the issue and promised to hold an international conference on the subject once in office. However, this was probably a tactic used by Bush to continue discussions regarding anthropogenic climate change and thus delay action.

With governments and scientists engaging in increasing dialogue there was a growing need to secure consensus on the causes, seriousness and implications of climate change. Governments were also keen to become involved in an international process of climate change research. A combination of increasing scientific support for the theory of anthropogenic climate change and strengthening political interest in the issue thus paved the way for a decisive initiative – the formation of the IPCC in 1988 (Hart and Victor, 1993; Paterson 1996a).

Oppenheimer (1989) credits the collective efforts of discussions at Bellagio and Toronto in 1988 with providing the catalyst to the formation of the IPCC. These workshops appealed for 'an agreement on a law of the atmosphere as a global commons or the need to move towards a convention' (Jäger, 1988 cited in Paterson, 1996a, p.31). It is also clear, however, that the motives for establishing the IPCC were largely political, in that the new institution created a means to draw governments worldwide into a process of decision-making about climate change (Agrawala, 1998a, p.617). More specifically, Vogler claims that the creation of the IPCC represented 'a successful attempt by governments (notably the US government) to assert control over the climate change research process' (Vogler, 1995, p.204). Both Nitze (1989, p.44) and Bodansky (1993,

p.464) also stress the role of the US government in promoting the IPCC as an attempt to respond to a problem that was at once both scientific and political.

Indeed, opinions within US government circles were themselves divided during the mid 1980s over the issue of climate change. The Environmental Protection Agency and some within the State Department supported the creation of a climate change convention in the face of opposition from other branches of the administration which held that too much scientific uncertainty still prevailed to justify action (Hecht and Tirpak, 1995). Specific political action against climate change was thus not an option at this stage. General agreement could, however, be secured for a compromise position that would see the establishment of an intergovernmental assessment mechanism – the IPCC. This initiative suited the various US government agencies involved, bought time and promoted international involvement; ultimately, too, it made a future convention a more realistic possibility (Agrawala, 1998a).

During early 1987 the WMO seemed the natural choice to sponsor the international assessment process, but it did not have sufficient expertise to cover some areas of climate change, such as policy responses. Consequently, the UNEP became involved, leading to the establishment of a joint intergovernmental assessment body. Negotiations between the WMO and UNEP led, in turn, to calls for all interested countries to be involved with and represented on an 'Intergovernmental Panel on Climate Change' (Obasi, 1988). The formal creation of the IPCC, under the auspices of the WMO and UNEP, followed in November 1988.

The new panel was composed of eminent climatologists nominated by their national governments, under the chairmanship of the Swede, Bert Bolin (Rowlands, 1995, p.75). The British representative, John Houghton, was selected to chair the Science Working Group (WGI). The scientific stature of Bolin and Houghton was important in encouraging a wider involvement of scientists and governments from around the world in the work of the IPCC, especially in the early stages 'when the Panel had no brand name recognition or prestige benefits to offer' (Andresen and Agrawala, 2002, p.45). The growing involvement of a core group of eminent scientists was thus vital in boosting the 'scientific credibility and political legitimacy' of the IPCC (Andresen and Agrawala, 2002, p.44).

These twin requirements of scientific credibility and political legitimacy also explain the enthusiasm of leading figures within the IPCC for securing the extensive involvement of scientists from developing countries in the work of the panel. The remit for the IPCC's formation provided specific financial support with which to engage scientists from the developing world. In part this reflected a recognition that many such countries were most likely to suffer severely from the effects of global warming (Kandlikar and Ambuj, 1997). But involvement was also intended to dispel a wider sense of disconnection from the issue of climate change expressed by some leading political figures in the developing world. Ultimately, a truly global agreement about the causes of climate change and the structure of a co-ordinated response would be necessary, involving developing as well as developed countries. It was also evident from the outset that the involvement of some developed states, not least the USA, in any preventative policy against climate change was likely to be dependent on some commitment to future action by rapidly developing states such as China, India and Malaysia.

In practice, the uneven geographical distribution of scientific expertise concerning climate change made it difficult to give the prominence hoped for to authors from developing countries when preparing IPCC reports (Kanlikar and Ambuj, 1997; Shackley, 1997). In response a Special Committee on the Participation of Developing Countries was established in 1989 (Paterson, 1996a, p.44; Rowlands, 1995, p.75). Overall, however, Andressen and Agrawala (2002, p.45) claim, the involvement of representatives from the developing world accelerated formal intergovernmental negotiations about climate change. A perception that the panel was more representative than any previous body was perhaps a key factor in securing more political weight for its scientific statements than achieved by any other studies (Paterson, 1996a). Alternatively, Shackley argues (1997, p.77) this may have reflected the status and external influence of a rather smaller group of scientists and policy makers who made up the active core of the IPCC. The impact made by the IPCC's statements was also a function of the strength of their message. In this respect the exclusion of many – but not all – prominent climate sceptics, whose opinions might have tempered the panel's published conclusions, is a further potential factor (Paterson, 1996a).

The initial aim of the IPCC as a vehicle for fostering research and shaping wider opinion in a co-ordinated fashion was to prepare an assessment of the scientific and

economic dimensions of climate change for the 1992 Rio Earth Summit. The resultant reports reviewed and assessed published scientific literature on climate change, its impacts, costs and possible policy responses (Andressen and Agrawala, 2002). The IPCC also offered an evaluation of scientific and technical issues for the UNFCCC.

Successive IPCC reports are widely seen as presenting 'a clear expert consensus on what is known and with what certainty'. The IPCC is thus characterised as the 'principal messenger' between scientists, governments and the public regarding the importance of climate change (Shackley, 1997, p.77). Similarly, Paterson (1996a, p.43) identifies the IPCC as the 'primary forum for coordinating policy research related to climate change and ... a forerunner to establishing formal negotiations towards international treaties'. Subsequent events have, however, revealed the problems inherent in this progress from 'scientific' to 'political' coordination. In part, such difficulties reflect not only the difficulties of framing and coordinating international policy, but also the nature of the IPCC itself. As acknowledged earlier there was much that was political in the creation and structure of the IPCC. The end result is a body that is well respected because its publications and statements are widely perceived to be based on sound science. But the IPCC has not secured – and indeed could not secure – total scientific consensus as an undisputed basis for the creation of a policy response. Moreover, the process of authorship of some IPCC reports has been subject to scrutiny and criticism, reflecting charges that the detailed presentation of content has been influenced by political considerations as well as scientific evidence (see also Section 2.5.1).

It is also important to acknowledge the politicisation of the wider international context within which the work of the IPCC would be considered. In this respect, the formation of the Alliance of Small Island States (AOSIS) in 1989 marked the emergence of climate change as a truly internationalised political issue. Anthropogenic emissions were recognised as being chiefly produced by developed nations, yet it was evident that developing nations would suffer the most from their effects; not least because they were less well equipped to deal with the consequences. Indeed, the formation of AOSIS reflected the concern of many of its members that their very 'existence is threatened by sea-level rise' (Jamieson, 2001, p.287). Developed nations were, therefore, argued to have key responsibilities to help developing countries, both in curbing climate change and in providing aid to mitigate its effects (Keesings, 2001). The response of President George Bush Senior, however, was to emphasise the need for scientific facts and further

research, rather than to offer any assistance to developing nations. Although policy actions were planned and scientific consensus was emerging, it is clear that there was still an emphasis on scientific research. By focusing on research and directing more money into the subject Bush could postpone political action, which he perceived to be against America's economic self-interest (Carpenter, 2001, p.314). It appears that this response from the USA, at this early stage in the politicisation of climate change, established the tone of future American participation in climate diplomacy. Despite appeals to the precautionary principle, the scientific uncertainty of the subject was now being used by some politicians as an excuse not to respond to the problem. Partly as a result, scientists' statements about climate change have become stronger through the 1990s, to try to force governments into effective action. At the same time, however, the scientific understanding of the subject was itself increasing. The Second World Climate Conference (1990), backed by the recent Working Group I (WGI) IPCC report, declared that if increases in greenhouse gas concentrations were not limited, the predicted climate change would place stress on natural and social systems to a degree not seen in the past 10,000 years (Environmental Defence Organisation, 2001). This led to serious international political concern and highlighted the need for a climate convention.

The establishment of the Framework Convention on Climate Change (FCCC) (1992) appears to have been a weak response by governments to the need to 'address the risk of climate change' by attempting to stabilise 'greenhouse gas concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference with the climate system' (Arts, 1998, p.100, see also Environmental Defence Organisation, 2001). Key international climate scientists, such as Bert Bolin and Sir John Houghton, Chief Executive of the UK Meteorological Office and co-chairman of WGI of the IPCC, (see, for example, the statement by Houghton *et al*, 1992, p.iii), were pushing for stringent emission reduction targets (Rowlands, 1995). However, the FCCC was only an agreement to the principle of emission reductions and it set no legally binding targets. It was not until 1997 with the introduction of the Kyoto Protocol that there was a real shift towards regulation – although there were no immediate moves to establish penalties for non-compliance (O'Riordan and Jordan, 1997). Moreover, despite the FCCC's invocation of the Precautionary Principle to argue that scientific uncertainty should not be used to justify policy inaction, such excuses for deferring political action remain common.

Although uncertainty still undoubtedly existed in climate science, James McCarthy, chair of the Advisory Committee for ICSU, (1996) claimed that debate over the reality of climate change no longer existed among 'worthy' scientists; the only contention now being 'the rate at which it is happening' (McCarthy, 1996, quoted in Gelbspan, 1998, p.23). Indeed, the majority of the scientific community accepted that global warming would have severe implications. Yet some contrarians still disputed it, arguing that the climate system would adjust to compensate for the anthropogenic emissions, thus reducing the terrestrial implications (see for example, Lindzen, 1995).

In 1997 more than 160 states, which were the parties to the FCCC, adopted the Kyoto Protocol (see Table 2.1). This legally binding convention obliged developed nations to achieve specific limits on greenhouse gas emissions by the years 2008-2012 (UNFCC, 1997). The protocol's emissions targets were hailed as an important first step towards the Framework Convention's objective of avoiding climate change. However, the Kyoto Protocol was criticised by both pro- and anti-environmental NGOs. Moreover, the attempts to finalise its terms at subsequent meetings of the parties quickly ran into trouble. Crucially, meetings at The Hague in 2000 failed to reach an agreement on the implementation rules that were prerequisites for most industrialised nations' ratification of the Protocol. The Hague conference ended inconclusively because of disagreements between the EU and USA over terms for achieving the reduction of greenhouse gas emissions. Consequently, decisions were postponed until 2001 (Pearce, 2000). In the meantime, the new US President George W. Bush requested that NAS produced a report analysing climate science. It supported the IPCC reports (2001 – WGI, WGII, WGIII), claiming that 'temperatures are in fact rising [and these] are most likely due to human activities' (NAS, 2001). This, however, had little effect on the public stance of the Bush administration. Like his father Bush Junior emphasised the uncertainty of the science and, therefore, insisted on further research before any effective action. Again this is counter to the FCCC's endorsement of the precautionary principle. In practice, Bush's stance strongly reflects the influence of businesses interest opposed to emission reduction targets, rather than actual uncertainty in climate science (Carpenter, 2001). Indeed, the domestic political context in the US is even such that Bush felt confident in taking on international opinion and withdrawing from further discussions of the Protocol. In the USA's absence, the Kyoto Protocol was eventually signed at the Sixth Conference of the Parties in 2001, committing signatories to reduce greenhouse gas emissions to the targets set four years earlier at Kyoto. However, a still greater level of

flexibility in the achievement of those targets was permitted than had been discussed in 2000. As Oliver Belgium, the EU's chief negotiator, stated, he would 'prefer an imperfect agreement that is living, to a perfect agreement that doesn't exist' (Pearce, 2001). Contention still exists over emission reduction targets and exact responsibility for action. On the 4th June 2002 the Kyoto Protocol had been signed by 84 Parties and had been ratified by 74 Parties (UNFCCC, 2002). President Bush and the majority of the Senate remain opposed to US ratification, declaring that scientific uncertainty is still too great to justify its targets (CoP 6, 2001; Environmental Defence Organisation, 2001). It is likely that the uncertainty in the science has been overemphasised by vocal sceptic scientists, such as Michaels, Balling, Singer and Idso and by anti-environmental NGOs like the Global Climate Coalition (GCC) which are supported by specific business interests. Thus, the US government has yet again used the weak excuse of scientific uncertainty to protect the economic interest of influential and powerful corporations.

With climate change becoming a legitimate issue for debate outside the scientific community, it is necessary to understand how the issue actually became politicised. What factor or factors caused the issue to enter the political realm? Were individual climate scientists significant in forcing the issue onto the agenda, or did mass scientific support do more to push the subject forward. The following section 2.4 will investigate the origin of the initial politicisation of the debate; whereas section 2.5 will provide a critique of key theories that attempt to explain the unfolding debate.

2.4 Understanding the Politicisation of Climate Science: The Context for Politicisation

Section 2.3 indicated the prominence that climate change had achieved on political agendas by the late 1980s. Although the emergence of modern environmentalism had begun the politicisation of the issue in the 1950s, it was not until the 1980s that global warming achieved prominence within society and on political agendas. However, the political visibility that the issue secured at the start of the 1980s was short-lived. It was not until the late 1980s that human-induced climate change achieved a more lasting place on the political agenda. Exactly how the greenhouse effect became politicised and, in particular, which factors propelled the issue onto the political agenda in the UK and

USA, deserve closer attention. Section 2.4 presents various suggestions as to why the issue became part of policy makers' agendas.

2.4.1 Push by Key Scientists

The presence of climate change on the political agenda can arguably be traced back to the late 1950s when key scientists, chiefly Wilson, Revelle, Houghton and Bolin, began establishing interest and support to advance discussions of climate change (see section 2.3. and 2.5). For instance, the concluding declaration of the Toronto Conference – 'humanity is conducting an uncontrolled globally pervasive experiment whose ultimate consequences could be second only to a global nuclear war' (Paterson, 1996a, p.34) – echoes Revelle and Suess's declaration in the late 1950s, thus highlighting the early attempts to gain wider societal support for climate change research and policy (see section 2.2.4). From the 1960s the issue could be characterised as becoming slowly politicised, reflecting the growing belief of a critical group of scientists in anthropogenic climate change.

The rise of environmentalism promoted by NGOs and the natural weather problems of the 1960s and 1970s provided a 'backdrop for the increased confidence with which scientists made claims about potential climate change', intensifying the politicisation of the issue (Paterson, 1996a, p.33). Wilson, who had been a key scientist in establishing an interest in climate change within a broader community in 1971, recognised the link between climate change and general environmental degradation, thus stimulating the uptake of the issue by NGOs (Kellogg, 1987). Wilson also made sure that statements from SMIC were accessible to NGOs. Climate scientists could, therefore, gain support, raise awareness and interest in the issue and further advance climate change on the political agenda from an early stage in the recent debate (see section 2.5).

The 1980s, however, can be pinpointed as the decade when the issue really established itself on political agendas. Climate science had developed. Scientists were more aware of, and better able to utilise, broader communication links and were, therefore, able to project strongly both their stance and the consequences of global warming. Protagonist scientists were convinced that human-induced climate change was responsible for the warming experienced during the 1980s and recognised the need for political action. Some commentators have suggested that political interest in the issue should be

ascribed to the influence of key individual scientists at this time (Hart and Victor, 1993; Mazur and Lee, 1993).

Throughout the 1980s, Hansen and his colleague Schneider also persistently attended conferences, congressional hearings and provided journalists with information about climate change, thus forming the contacts necessary to advance their arguments. Hansen is credited with being the 'primary scientific contributor who raised nearly the first and persistently the strongest public alarm' about global warming in the USA (see section 2.3.4). His words were also reported in the UK (Mazur and Lee, 1993, p.694, see also Gribbin, 1990b, Paterson, 1996a).

In Britain, Houghton too was edging climate change into the policy arena during the 1980s. He actively cultivated political and media contacts to raise interest in the subject. By the late 1980s, he had become friendly with Margaret Thatcher and, together with Sir Crispin Tickell, was able to persuade her to set up the government-funded Hadley Centre, as a new focus for UK research into climate change (see section 2.5).

2.4.2 Push by Pro-Environmental NGOs

The politicisation of climate change can also partly be attributed to NGOs shifting the focus of their campaigning from local to global environmental problems. Global warming was therefore taken up as a lobbying issue. As early as 1963 the US pro-environmental NGO, the Conservation Foundation, published what seems to have been the first report on the issue from an NGO source (Kellogg, 1987). At this time, developed countries economies were thriving and, perhaps as a result, western societies became increasingly concerned over environmental problems (O'Riordan, 1981; Pepper, 1984). The economic boom had taken care of many peoples' material needs, thus they turned their attention to meeting non-material goals, such as combating environmental degradation and anthropogenic climate change by joining NGOs. Furthermore, anxiety among the lay public rose about the possible consequences and implications of a steadily growing worldwide population. Thus, concern increased over the limited stock of finite resources such as coal, oil and gas. The strengthening public interest in environmentalism from the 1960s helped the 'campaign' against climate change gain further support and influence political agendas. Pepper (1984) and Lowe and Goyder (1983) claim that the economic boom increased public interest in

environmentalism because people are more inclined to react against highly materialistic values, changing their focus from materialism to post-materialism. Conversely, during recession the enthusiasm for the environment diminishes. At times when economic growth, employment and national security are threatened environmental issues are displaced from the hierarchy of importance (O'Riordan, 1981, pp.19-20).

Public concern for the environment, however, appeared to be transitory. Downs' 'issue attention cycle' may explain this wavering interest in climate change. He claims that when an important subject initially achieves prominence there is enthusiasm (albeit short-lived) about society's capacity to deal with the perceived problem (Downs, 1972). However, growing realisation of the complexity of the issue and the likely scale of costs of corrective action and demand on resources causes interest to dwindle. Lowe and Goyder (1983, p.31) also note how 'new issues arise which can exert a more novel and powerful claim on public attention'. This perspective suggests that the decline in attention regarding climate change is the result of other prominent issues emerging. Mazur and Lee (1993, p.696) argue that the appearance of the Nuclear Freeze movement in 1982 (to halt the world-wide production of nuclear weapons) removed specific attention from climate to nuclear winter climate scenarios. Edwards claims, however, that the nuclear winter topic 'elevated the general issue of anthropogenic climate change to front-page news' (Edwards, 2001, p.49). As a result of the nuclear freeze movement, however, new research areas relating to climate change arose, thus creating the opportunity for climate scientists, such as Schneider, to investigate nuclear winter scenarios upon the climate (Joyce, 1984). The improved relationships between Gorbachev and Reagan and the agreement on arms limitation eventually reduced the prospect of nuclear war, and moved attention, by default, back to anthropogenic climate change (Edwards, 2001, p.50).

The 1980s saw a renewed economic boom, which arguably shifted public attention back to environmental issues. An UK opinion survey highlighted that in the late 1980s 35 per cent of people regarded the environment as the most important issue of the time (McCormick, 1995). This was a product of changing societal perceptions of global environmental problems. NGOs once more achieved a rise in membership (Table 2.2). Unlike the 1960s, however, more NGOs showed an interest in global warming, directing their efforts towards the new international environmental problem. For example, activist members of the Union of Concerned Scientists shifted their resources

from the Nuclear Freeze issue to anthropogenic climate change. McCormick (1995, pp.157-58) also highlights how pro-environmental NGOs broadened their focus from nature protection to wider environmental concerns. At the same time, they incorporated more politically influential methods to achieve their goals such as activism and lobbying. Thus by 1990 an evident shift had occurred from the focus of 'regional and local issues to an ensemble of new problems with world wide-scope, especially climate change, ozone depletion, destruction of the rainforest and mass extinction of species' (Mazur and Lee, 1993, p. 681).

The politicisation of climate change can thus be attributed in part to the wider growth of interest in environmental issues as an international problem. Capitalising on the public interest in the environment, other pro-environmental NGOs intensified their lobbying for CO2 emission reductions from fossil fuel combustion. With growing public interest translating into an increase in membership numbers, pro-environmental NGOs became better organised, were able to mount more extensive campaigns and greater access to the media. For instance, between 1984 and 1989 Friends of the Earth (FOE) were able

Table 2.2: Increases in membership of major environmental groups 1971-89

	1971	1980	1985	1989
Greenpeace		10,000	50,000	320,000
FOE*	1,000	12,000	27,000	120,000
WWF*	12,000	51,000	91,000	202,000
Ramblers	22,000	36,000	50,000	73,000
National Trust	-	950,000	1.32m	1.75m
RSPB*	98,000	321,000	390,000	433,000

Sources: McCormick (1991, p. 152); Garner (1996, p. 64)
*Friends of the Earth
*World-Wide Fund for Nature
*Royal Society for the Protection of Birds

to increase their staff members by 900% and Greenpeace by 570% as an outcome of their enhanced campaigning (Garner, 1996, p.65; McCormick, 1991, p.155). This further heightened their public profile and their influence within the policy making process.

The achievement of a critical mass of interest in climate change by the end of the decade prompted pro-environmental NGOs to form a coalition to increase their political effectiveness. Thus in 1989 the Climate Action Network (CAN) was established. Over 250 organisations joined CAN (initially only Northern NGOs, but subsequently incorporating Southern NGOs), including Greenpeace, WWF and Friends of the Earth. These pro-environmental NGOs still hold the common aim of reducing greenhouse gas emissions (Climate Action Network, 2001). By the end of the 1980s, NGOs had generally gained sufficient ground within the political arena to be permitted to attend intergovernmental conferences and contribute to report agendas (Jasanoff, 1997). The inclusion of environmental NGOs is illustrated by the 1990 Bergen conference on climate change when organisations were allowed to participate, and consult politicians during the conference in an 'attempt to bring democracy to the Bergen Process' (Brown, 1990, p.27). By 1992 environmental NGOs had even greater influence at conferences. The UNFCCC granted them the right to contribute to policy procedure, in the form of critiquing drafts that emerged from negotiations and presenting their views in official meetings (Jasanoff, 1997; Gough and Shackley, 2001; Rowlands, 1995, p.239). Accordingly, their efforts have been recognised in Article 7.6 of the FCCC.

However, the dramatic expansion of environmental groups came to an end in the early 1990s. For example, FOE experienced a 10 per cent reduction in income during this period, with Greenpeace experiencing a similar fall, some of which may have been related to the economic recession at the beginning of the 1990s (Garner, 1996). By this time, however, climate change was firmly placed on the political agenda. It appears, therefore, that economic expansion initially in the 1960s and again in the 1980s, was a significant factor in stimulating the rise of environmental concern and gave the opportunity for the issue to gain heightened public attention through NGOs uptake of climate change.

2.4.3 Heightened Political Interest in Climate Science

Against a backdrop of environmentalism, climate change gained greater publicity as the world hit an energy crisis in the 1970s through to the early 1980s. Industry and publics were concerned about the potential exhaustion of fossil fuel resources. However, climate scientists and environmental NGOs which had recently adopted the issue saw this as an opportunity to generate further interest in climate change by emphasising the

possible impact of alternative fuels to oil, such as synthetics, upon the concentration of atmospheric CO_2 (Christiansen, 1999). This was perhaps the first evidence of a revival of interest in renewable energies. Governments were, therefore, prompted into action to investigate environmental concerns. Mazur and Lee (1993, p.695) argue that the US Environmental Protection Agency (EPA) and NAS issued reports to examine the energy-related concerns about global warming in 1983, which brought heightened media attention and raised public anxiety over the potential severity of climate change. However, it was probably the effect of these reports coupled with the influence of key individuals that increased the profile of the issue. Nevertheless, governmental concern was transitory. Indeed, environmental issues are often the last to be politically recognised because they do not retain public interest during economic recession and have a short-lived issue attention cycle. They are, therefore, highly susceptible to being displaced by other higher priority objectives. With the recovery of cheap and plentiful oil supplies by 1984, interest dwindled in synthetic fuels and associated climate problems (Mazur and Lee, 1993, p.694). Politicians now focused on seemingly more urgent matters of the time, such as the prospect of a nuclear war.

The discovery of the thinning ozone layer over Antarctica, during the mid 1980s, again focused political interest upon environmental problems. Connections were drawn between climate change and ozone depletion, thus raising concern about anthropogenic climate change. The issues were, therefore, frequently tackled together, moving climate change back into the political arena. For instance, the American Congress addressed both subjects concurrently. Although ozone depletion had greater priority within political agendas between 1985-7 the apparent success of the Montreal Protocol to phase out production of CFCs in 1987 encouraged diplomats to place climate change on their agendas (Paterson, 1996a, p.30). The political response to ozone depletion provided apparent guidelines for policy makers on how to respond and deal with anthropogenic climate change. The Villach conference for example, called for global agreement on the future treatment of the atmosphere and expressed the need to move towards a convention similar to that developed for ozone. However, by the end of the 1980s and beginning of 1990s, policy makers realised that climate change could not be tackled as quickly as ozone depletion. As Elliot (1998, p.60) notes: 'If Benedick [the Chief US negotiator] was able to refer to the Montreal Protocol as the impossible accord it was nothing compared to the difficulties of addressing climate change'.

The political importance in climate change was further increased in the 1980s by mass media hype in the USA and UK linking natural environmental catastrophes to anthropogenic climate change. Natural disasters dominated the decade. Record-breaking temperatures were recorded within North America and unusual weather patterns occurred throughout the world. For instance, China suffered floods and droughts; Africa, India, Brazil and Bangladesh experienced floods; droughts occurred in the USSR and hurricanes hit the Caribbean (Christiansen, 1999; Paterson, 1996a; Rowlands, 1995). Statistics also showed that the 1980s was then the hottest decade globally on record. With the mass media relating these natural weather events to anthropogenic climate change, policy makers became more responsive to the problem (Mazur and Lee, 1993; Paterson, 1996a; Rowlands, 1995). The politicisation of climate change can thus be attributed to a broad range of factors that collectively pushed the issue onto policy agendas. Climate scientists' individual entrepreneurial skills, backed by the weight of the scientific community, alongside a rise in public interest in environmental issues, and a push by pro-environmental NGOs together ensured that the issue secured a more prominent place within the political arena by the 1980s. Yet, the case shows that the scientific community could not single-handedly establish the issue on the political agenda. Thus, climate scientists were interacting and networking with NGOs, policy makers, the media and, to some extent, the public. This highlights the need to investigate the relationship between climate scientists and these 'outside forces'.

2.5 Explaining the climate debate

The politicisation of climate change altered the nature of the scientific process. Increasingly, research became directed towards influencing climate policy (O'Riordan & Jäger, 1996). Faced with highly uncertain issues such as climate change, policy makers turned to climate scientists for information. The relationship between scientists, science, politics, economics and society therefore changed, with sponsorship of climate research becoming a more controversial issue. Three key commentators provide different perspectives on how these relationships can be understood. Their views provide a constructive contrast concerning the practice of climate change scientists. Examining the means and motives of climate scientists through these important commentaries will provide part of the foundation for the construction of a theoretical perspective in Chapter Three.

Hart and Victor (1993) stress the role of individuals in advancing climate change as a political issue. They claim that certain 'elite' scientists have been individually influential in the debate. Paterson (1996a), by contrast, stresses the impact made by climate scientists as a collective community. Scientists actively working together, creating a critical mass, are argued to have been more influential on the policy-making process than any individual scientists. Boehmer-Christiansen (1994a & 1994b) suggests a conspiratorial egotistical approach whereby protagonist climate scientists, previously regarded as independent and influential in their own right, have over-stated their position on the subject to gain further research funding. Paterson and Boehmer-Christiansen also recognise the importance of specific authorities like the IPCC. They note that such bodies have a vested interest in sustaining themselves and their research, because they produce and control a large degree of climate knowledge and are to a degree 'empowered' by their expertise. However, the perspectives of Boehmer-Christiansen and Paterson are very different (Haas, 1990; Paterson, 1996a).

2.5.1 Theoretical Perspectives

All three views imply that scientists are politically active, but their interpretations of the principal role played by scientists in the climate change debate differ. Hart and Victor (1993) suggest that scientific 'elites', that is leading scientists and administrators (Mulkay, 1976), are influential figures in climate policy and should be seen as independent actors in their own right. They act as entrepreneurs taking advantage of 'temporary opportunities' to further their own agendas (including opportunities to gain financial support for research) in the political arena by recognising occasions when they can utilise their contacts, emphasise their expertise and highlight the seriousness of the issue (Hart and Victor, 1993, pp.643-4). Thus they believe that scientists become influential mainly because of their career position and personality, enabling them to gain respect, network and be entrepreneurial. Hart and Victor identify Robert White, (Chief of the US Weather Bureau), Roger Revelle (Director of the Scripps Institute of Oceanography) and Thomas Malone (Chairman of the National Academy of Sciences' Committee on Atmospheric Science) as important scientists involved in both scientific and political realms between 1957 to 1964. Paterson and Boehmer-Christiansen consider a wider time scale, yet specifically focus on the two decades when climate change became politicised. Thus, developments post 1974, the date at which Hart and Victor end their study, need also to be considered to contextualise fully the climate

debate. Without consideration of a longer time scale Hart and Victor's work offers only an incomplete contextualisation of the role of elite individuals.

Although Paterson identifies the importance of mass scientific support, claiming there is a 'community' of scientists working together for societal responses, he also recognises well-respected figures as influential in popularising the issue from as early as the 1970s. These individuals, such as Chair of the Climate Board of Canada, Kenneth Hare, had international contacts and participated in transnational conferences. They are not, however, recognised by Hart and Victor. Neither of these accounts appears to identify Carroll Wilson as a key scientist. He is seen as a significant figure by Hart and Victor, but not a member of the 'elite'. It could be argued, however, that he is an elite scientist because of his significant involvement in the study of climate change during the 1970s. He identified the need to link environmental concerns with climate change to gain more funding and policy attention. Through organising SCEP and SMIC he managed to reconstruct the climate issue as a threat to the 'valued resource' of the environment. Most importantly, he also succeeded in integrating the reports into the UNCHE (Hart and Victor, 1993, p.666). Furthermore, he selected a supporting steering committee that included the eminent scientists Roger Revelle and Thomas Malone, who helped to establish a critical mass of scientists to support the ideas generated by SCEP and SMIC. Wilson also made sure that the subsequent reports adopted an environmentalist tone to attract the interest of NGOs. The influence of Wilson and the support of the elite scientists was evident to the extent that more funding was allocated to climate research (Hart and Victor, 1993). Although his lack of prior involvement eliminates him from Hart and Victor's list of elite scientist, Wilson's contribution to raising the profile and gaining both political and scientific support for the issue should not be understated. Furthermore, neither Paterson nor Hart and Victor consider the Russian scientist Budyko as an eminent figure. He had played a significant role in the development of climatology by calculating the heat balance of the earth's surface (Asahi Glass Foundation, 1998). Yet there appears to be a good cause for according him influence, as a reflection of his scientific research, rather than his entrepreneurship. Thus, previous studies have some limitations as they do not thoroughly consider other international individuals. This lack of recognition extends to Hansen's influence and entrepreneurship during the 1980s and Schneider's subsequent efforts to increase public awareness of climate change.

Ultimately, however, Paterson argues that the total weight of scientific opinion is more important than any individual scientist's actions in establishing the issue on the political agenda. He suggests that it is through their collective endeavour that climate scientists achieve influence. This is specifically seen through Working Groups I and II of the IPCC. Paterson refers to an epistemic community model of scientists (cf Haas, 1992). He thus stresses the shared characteristics among the group – normative and principled beliefs, causal belief, notions of validity and a common policy enterprise drawing on their consensual statements, for example on causal beliefs – that make climate scientists influential. By contrast Hart and Victor's line of argument implies that elite entrepreneurial scientists led the IPCC. They argue, therefore, that the IPCC provides only an illusion of a community. It is better understood as a constructed group formed and controlled by the key scientists. The IPCC became politically empowered by a process that really began in the 1970s. Key scientists established international scientific and political interest in the subject, leading to its politicisation in the late 1980s. The critical mass of scientists that form the majority of the IPCC justify the key opinions of the few important scientists that drive the group. However, the reports produced by the IPCC, by which we judge this group are often largely the work of the lead authors such as Houghton and Bolin, and policy makers rather than the whole scientific group. Thus, the community could be said to be influenced and compelled by the knowledge and influence of particular scientists who act as goal-seeking individuals within the IPCC. It appears that these key persons have created an illusion of a cohesive community of scientists, thus, policy makers and the public assume there to be an epistemic community, which co-operates amongst itself and delivers group consensual agreements. These key scientists have established strong international contacts, appear well respected among their peers and are charismatic and politically driven having pursued their own agenda since the 1960s and 1970s. Viewed in this way, the IPCC is not a consensus community but a quasi-constructed deception, controlled and influenced by key scientists.

Both Paterson, and Hart and Victor can be criticised for not recognising sufficiently the involvement of NGOs. In the early 1960s the Conservation Foundation help raise the domestic political profile of the climate issue by producing reports which effectively increased the US government's interest in climate change leading to the subsequent production of a White House study on global warming (Rowlands, 1995). The influence of NGOs has further been increased by their subsequent inclusion in international

conferences such as those associated with the FCCC (Gough and Shackley, 2001). Paterson also downplays the significance and important of the Toronto and Villach conference which promoted an alliance between key members of scientific and political establishments (see section 2.3.2).

Boehmer-Christiansen's (1994a, 1994b) position could be seen as a powerful criticism of both the preceding ideas. She argues that far from being influential and independent operators, concerned for the greater good, scientists are at best opportunistic agents driven by the need to get money, and, at worst, may function as politically naïve pawns who are used or bought by other interests. Such arguments have themselves inspired criticism for being too one-sided (Shackley and Skodvin, 1995). Boehmer-Christiansen suggests that the members of the IPCC have constantly reframed its position to get the best grants. Initially, they overemphasised the threat of the enhanced greenhouse effect to stress their own policy relevance, then by achieving consensus on the issue they managed to consolidate their position. Once the issue reached the political agenda, the IPCC highlighted uncertainties ensuring that their expertise remained applicable (Boehmer-Christiansen, 1994a, 1994b). For instance, the IPCC chairman, Professor Bolin, is charged with contradictory behaviour in first emphasising the dangers of continuing with a 'business as usual' approach with respect to reducing greenhouse gases, yet then calling 'for more research funds rather than any specific emission reduction targets' (Boehmer-Christiansen, 1994b, p.190). Equally, the Executive Director of the World Meteorological Organisation, Professor G O P Obasi, appealed – with full UK backing – for further research to reduce uncertainties. This gave governments time to delay action by supporting further research (Boehmer-Christiansen, 1994b). Although Paterson points out that the IPCC is politically driven and 'goal seeking', he stresses that this is because the scientists involved are motivated by their understanding of the seriousness of the issue. He argues that this is a characteristic of an epistemic community and endemic among active policy-orientated expert groups. Paterson contradicts Boehmer-Christiansen's claims that the IPCC stressed the uncertainties in climate science to maintain its own influence in the new era of politicised climate science. Instead, he claims that once climate change became accepted on the world stage other actors within national bureaucracies actually reduced the IPCC's role and influence (Paterson, 1996a). However, the IPCC is still regarded as the primary body of official climate science and knowledge. Its reports remain key advisory papers to the UNFCCC. It appears that the influence of the IPCC has not

necessarily diminished, but interest in the issue has decreased (see section 2.4.2). Furthermore, Paterson mentions the involvement of other groups in the climate debate such as the GCC, which he believes have helped to reduce the influence of the IPCC. An alternative reading, however, might conclude that the GCC's intervention has injected a renewed ferocity into the climate debate, encouraging a stronger stance on the part of the IPCC (Houghton *et al*, 2001).

Boehmer-Christiansen argues that uncertainty in climate science has provided a basis for governments to impose unsatisfactory environmental policy, and simultaneously call for extensions in research, thus creating a 'win-win' scenario for the scientific community and governments. However, governments would be strongly criticised if they endorsed policy without firm scientific evidence of both their necessity and the seriousness of climate change. Thus, in this case a 'win-win' scenario could be translated as a 'no-win' situation for society. Hart and Victor make a similar point with their observations that in the early 1970s politicians could appear conscientious about the environment because of the high public concern and thus gain further support; yet would not act, claiming that the problem was not immediately threatening (Hart and Victor, 1993).

Boehmer-Christiansen does not clarify the relationship between the IPCC and the wider scientific community. Thus, it is implied that all share the same motivations (Shackley and Skodvin, 1995). Both Paterson and Boehmer-Christiansen emphasise the consensus within the IPCC. Paterson claims that IPCC members have 'shared notions of validity' (Paterson, 1996a, see also Haas, 1992). For example, they generally agree on the various methods used to indicate the changing global average temperatures. However, controversy exists regarding the best method to gain scientific results. As Paterson points out, debates have existed over the 'hegemonic status' of GCMs within climate modelling although this is also related to access to research funding (see for example, Lunde, 1991 and Shackley *et al*, 1998). Furthermore, the opinions of IPCC scientists vary regarding the seriousness of the issue. Certain members of the IPCC, such as Lindzen, are very sceptical about global warming (Lindzen quoted in Pearce 1997). Thus, the IPCC includes members holding a broad set of opinions and cannot really be considered as a consensus group (see, for example, O'Riordan and Jordan, 1999, pp.82-83).

Boehmer-Christiansen's theory, like that of Hart and Victor and, to a degree, Paterson, suffers from a lack of recognition of the broad number of players involved in the debate, such as pro- and anti-environmental NGOs. The latter may exert a considerable influence upon the climate debate. Indeed, some climate scientists, such as Michaels, Singer, Idso, and Seitz are asserted to have become paid agents of powerful sponsors (Beder, 1999; Gelbspan, 1998). Anti-environmental NGOs have sponsored such scientists to promote their scientific stance, gain support and thus minimalism the impact of protagonist scientists claiming the seriousness of the issue and the need for related policy. Scientists and their NGO sponsors may thus have an important role in furthering the interests of powerful corporations which have a vested interest in seeing that CO_2 emission reduction policies are weakened or, ideally, go unratified.

2. 6 Conclusion

The involvement of international scientific and international institutions has changed the context in which climate research is undertaken. Climate research now has important political dimensions, even though the science is still uncertain. Politicians rely on climate scientists for information. Thus, climate research is now more explicitly intended to inform policy (O'Riordan & Jäger, 1996). Recognising this change in relationship, there is a need to explore the actual association of climate science and scientists with social, political and economic forces. Is it really the case that IPCC members and other climate scientists are using the issue as a means to direct more funding into the area for personal motives (Boehmer-Christiansen 1994a&b)? Vested interests create a further dimension to this complex relationship between climate scientists and science and the broader issue. What roles do institutions with vested interests play and how influential are such bodies? Indeed, to what extent has sponsorship of climate research become an issue?

To reflect upon all these points requires a broader conceptualisation of the role of science and scientists within society. All these commentators, Boehmer-Christiansen, Hart and Victor and Paterson, imply a need to question the integrity and objectivity of climate science and scientists. Furthermore, the industrial sponsorship of research has led to claims that tainted science is being produced (Beder 1997, 1999; Gelbspan, 1998). We might, therefore, question the status of climate science now that it is involved in policy decisions. A detailed investigation of this issue, however, requires a

greater and more theoretical understanding of the potential constitution of relationships between scientists, institutions and the broader societal context. It is to this task that the next chapter turns.

CHAPTER THREE

Theory: Comprehending the Climate Debate

3.1 Introduction

The politicised climate debate suggests a connection between climate science and scientists on the one hand, and society on the other. It points to the involvement of contextual actors – social, political and economic – in the production of climate science. This recognition both calls into question traditional theoretical representations of science as a separate sphere of human endeavour and focuses attention on the need for more detailed study of the place of climate science and scientists within modern western liberal societies. This chapter aims to begin this exploration of the ways in which the production of scientific knowledge is embedded within political, economic and social structures, by advancing a theoretical framework for the study of climate science that follows in Chapters Five and Six.

Consideration of the impact that external forces may have upon the scientific agenda – perhaps particularly through their influence upon the availability and distribution of funding for scientific research – must be set against further attention to the roles played by scientists themselves. It may be true, as some commentators have claimed (such as Beder, 1997, 1999; Boehmer-Christiansen, 1994a, 1994b, 1997; Gelbspan, 1998; Karliner, 1997; Rowell, 1997), that identifiable commercial and political actors have sought to influence debate about climate science through sponsorship of specific research and particular scientists. Indeed, given the status of climate research as contentious and politicised science with important implications for economic and social policy, it would be odd if no such engagement could be detected. Its presence does not, however, prove that claims for the intellectual autonomy of science should be entirely discounted. Attempted influence in specific cases does not necessarily translate into the complete determination of the content of a scientific field by external paymasters. Hence the need to know more about the attitudes and practices of climate scientists.

It is also the case that the expertise which scientists themselves possess confers a potential ability to influence the wider political and economic agenda. This does not mean that policy-makers are bound to follow the logic of scientific arguments, but the very existence of climate change as a policy issue stems initially from scientific research. It is evident, moreover, that national and international policy makers have drawn subsequently upon the work of climate scientists to inform their decisions, and that the character of climate science has itself changed over time, from work that is relatively abstract, to research that is increasingly applied. Acknowledgement of the policy relevance of climate science, however, only complicates further our efforts to understand the relationships between science and society. On the one hand a status as a source of expertise may be seen to reinforce the case for scientific independence and authority. Yet, as noted above, it is precisely this link between science and policy that provides the rationale for the alleged attempts by particular commercial and political interests to influence the production and interpretation of climate science.

Any attempt to document these relationships in practice will be stronger if we first refine our theoretical understanding of the potential links between science and society. Hence the current chapter advances a critical exploration of existing theoretical constructions of the potential relationships between society and the production of scientific knowledge. This review is not intended to provide an exhaustive critique of such theories; rather it considers a series of mainstream models. In so doing it helps to focus attention not simply upon the contested understanding of relationships between science and society, but also upon the constitution of 'society' itself. Implicit in the discussion so far has been the need to consider the nature of relationships between economic and political actors, given that their interests in relation to the content and conduct of climate science may not be identical. Theoretical constructions of this relationship between the economic and political, and its implications for the sponsorship of science thus form an important element of what follows.

3.2 The Place of Science

3.2.1 Science and Society as Separate Realms?

Early theories suggested that science was largely separate from and, therefore, uninfluenced by, society. Normative studies presented the production of scientific

knowledge as being objective and uninfluenced by societal or contextual forces, or by vested interests. Science, as a sphere detached from society, was thus motivated solely by the pursuit of greater knowledge. Such thinking is still widely reproduced today and offers an idealised view of science. It has, however, been subject to increasing critical scrutiny (for example, Irwin and Wynne, 1996; Lyotard, 1979), reflecting a growing understanding of the links between science and society in practice.

Classic statements of the ideal of the production of scientific knowledge as neutral and value-free have been made by Merton (1973) and Polanyi (1962), amongst others. The latter argued that:

> scientific research is motivated not by any practical considerations but by the pure search for knowledge ... [the] primary motive for doing science is curiosity and a passion to know ... [and] to increase our understanding of the world (Polanyi, 1962, p.54-73).

Merton (1973) argued that scientists have a strong and distinctive ethos, based on sharing information in the pursuit of truth. Such evidence has a vital role in the construction of new scientific knowledge, for, Merton indicated, scientists are sceptical about their research results unless these are fully supported by further evidence. Merton acknowledged that many scientists are driven to pursue their careers out of self-interest, yet he believes that the ethos of science binds scientists to conform collectively to the rules and expectations of science (Merton, 1973; see also Hess, 1997). Bridgestock (1998, p.37), echoing Merton, suggests that scientists feel obliged to conform outwardly to an ethical, unselfish image, no matter what their individual ambitions, objectives and sources of funding. The progressive-positivist model similarly presents scientists as neutral and the producers of value-free research; it is for this reason that their work is used to inform the actions of external decision-makers. Scientific legitimacy thus rests on its image as a non-ideological sphere that is respected within society (Lipschutz and Conca 1993, p.132). All these models, however, seem to present an over-simplified account in denying the contested link between the production of scientific knowledge and societal and political values.

A somewhat different normative model of science is presented in Kuhn's (1962) paradigm shift theory. But Kuhn too sees science as an essentially self-contained enterprise in which internal factors influence – if not determine – the development of concepts and preferred theories. Each scientific view is grounded in a community of

scientists who are committed to a particular worldview. This is the normal condition of science, which is only occasionally overturned by the accumulation of contradictory evidence. The latter eventually raises such tensions between what is known about the state of the world and existing attempts to explain it, that radical revision of scientific understanding is required – a paradigm shift – leading to the creation of a new world view (Sardar, 2000). Typically, it is argued, established scientists are trained to think within the framework provided by an existing paradigm and, therefore, find it difficult to conceive of the world in any other way (Hess, 1997; Kuhn, 1962; Lipschutz and Conca, 1993). Scientists habitually work within a paradigm and consequently look for data that support and refine existing theoretical constructions. They arguably have a vested interest in maintaining an established paradigm because it provides the academic foundation on which their existing work and, thus, their academic reputations and careers are based. Once a paradigm is established within science to serve as the basis for further enquiry, it is presented to society as self-contained expertise (Lipschutz and Conca, 1993; Sardar, 2000). This display of authority, allied to a normative interpretation of society, is argued to enable scientists to retain their autonomy. However, it is Kuhn's argument that scientists may initially ignore evidence that does not 'fit' an established paradigm (Kuhn, 1962).

Kuhn's theory offers a perspective on the internal dynamic of science. It also recognises that debate and contention characterise the process of science. Yet he shares with Polanyi and Merton an internalised view of science, which does not address the wider social context within which scientific research is undertaken. Relationships between science, polity, and economy, and contest regarding the constitution of society thus still remain to be considered.

In practice it is clear that some scientists may well be aware of the implications of their work, not least because of its close association with policy-making in many instances. Moreover, as Etzkowitz (1993, 1994) notes, scientists may utilise their knowledge for profit. This pursuit of explicit financial, political or career goals seems at odds with the characterisation of science as a value-free quest for greater knowledge. Hence Forge (1989) asserts that scientists' 'goals' are related to their values. This realisation may, however, only serve to introduce an alternative and more calculating logic for claims of scientific objectivity, directed at preserving the privileged status of science as a way of understanding the world. A less cynical reading of a goal-driven science might be that

its practitioners pursue the research which they see as producing the greatest public benefit. While a praiseworthy enterprise, this still compromises the ideal of science as value-free. In a field such as climate science there may be particular tensions between the ideal of neutral science and a reality of wider societal engagement. Some scientists may genuinely believe that they are undertaking value-neutral research, yet also feel driven by a need to warn society about the potential dangers of climate change. The former belief is perhaps not surprising given the individual researcher's socialisation into a broadly normative position by the scientific community in general. Yet this does not prevent their research being compromised by the constraints imposed by particular funding sources, or their results being (mis)used by interested parties to argue for a particular policy response. The fervour with which some scientists defend their position of 'neutrality' may suggest a failure to think beyond the established normative rhetoric. But it perhaps also indicates a lack of self-belief and a degree of indifference and suspicion towards the external political world that their research may inform. There seems almost to be a psychological need for some scientists to believe that they are doing value-free research.

If we accept that the attempt to present science as a non-ideological sphere is itself the outcome of a particular – and powerful – ideology many of the established 'certainties' about the status and conduct of science begin to melt away. Any attempt to determine the extent to which scientists themselves have been consciously complicit in the perpetuation of the 'myth' of scientific neutrality seems likely to lead only to frustration. It is important, however, to look beyond normative theories to consider how science might be connected to, and influenced by, societal forces.

A useful point of departure is offered by Breyman's (1993) argument that the scientific community is influenced by the same factors as other large institutions: 'competition for funding and honours, bureaucratic strife and turf battles, fraud and egotism' (Breyman, 1993, p.133). Presented in this way, science and scientists display the same limitations as are evident in other social institutions. Indeed, it would be surprising if this were not the case. Furthermore, the 'growing vulnerability of science and the evolution of the new ecological paradigm' has led to charges that scientists have been tainted by their close association with the policy-making process (Breyman, 1993, p.133). This is because the distinction between ends (presumably selected politically) and the means (presumably selected scientifically) becomes blurred; even to the 'extent that politics

comes to shape science and science becomes politicised' (Breyman, 1993, p.134). Breyman claims that this type of 'politicised science' is:

> science that has been tarnished in the rough and tumble of the policy process, compromised by the schemes of non-scientists. It is not exactly corrupted science, that sort bent to the will of political or corporate overlords, but it has been delegitimized to some extent nevertheless.... [It is characterised] by those instances when technology breaks down or is challenged (Breyman, 1993, p.134).

If the reality of science is of an activity that is 'tarnished' and 'delegitimized' then we have departed significantly from the benign image of scientists as disinterested searchers for 'truth'. Yet even if scientific practice falls a long way short of such ideals, normative theories retain some value in the development of a theoretical and methodological framework. This is precisely because they help to focus attention on the extent to which, and the ways in which, scientists depart from the ideal. Thinking in this way also highlights the need to look beyond scientists' common self-characterisation of neutrality – whether naïve or consciously calculating – to identify the ways in which they are influenced by societal forces. Normative models provide a base against which to assess the validity of alternative theories. But it is clear that we cannot sustain the notion that science and society are separate realms. It is particularly important to question the notion of scientific objectivity when we are dealing with an environmental issue – or indeed any issue – that is highly politicised, controversial, scientifically uncertain and attracts strong and sharply opposed vested interests.

3.2.2 Science and the Wider World

If we accept that the scientific process does not take place within a vacuum, we need to consider alternative constructions of the relationships that link science and society. The quote from Breyman above reminds us of the potential presence of political and commercial actors. A more specific attempt to identify such influences upon the conduct and content of science is presented in Figure 3.1. The key elements within the network of relationships outlined here are 'business', 'the state' and 'science'. These interests are seen to be bound together through ties of mutual dependence that reflect the desire of business and state for the knowledge produced by science, and the need of science for funding that originates chiefly with state and business. The latter tie reflects a reality expressed by Wible (1988) who notes that..

> scientific research requires the efforts, time, and talents of some of the very best minds and research teams in the world and the expenditure of significant sums of material and financial resources...there is an economic dimension to almost every aspect of science (Wible, 1988, p.1-3).

Figure 3.1 is also intended to draw attention to the presence of other actors – including a range of NGOs and media interests – which may maintain some degree of independence as consumers and sponsors of scientific knowledge. Moreover, individual scientists will construct their own particular and more limited network of connections, rather than necessarily becoming involved in all the links outlined in Figure 3.1. For instance, a university scientist may receive research funding from the state – via a research council – and from business – in the form of commercial sponsorship. Whilst working on a project a scientist may also make media appearances to explain and publicise the research. It can be seen, therefore, that in such a case the broader context of scientific work has four major dimensions:

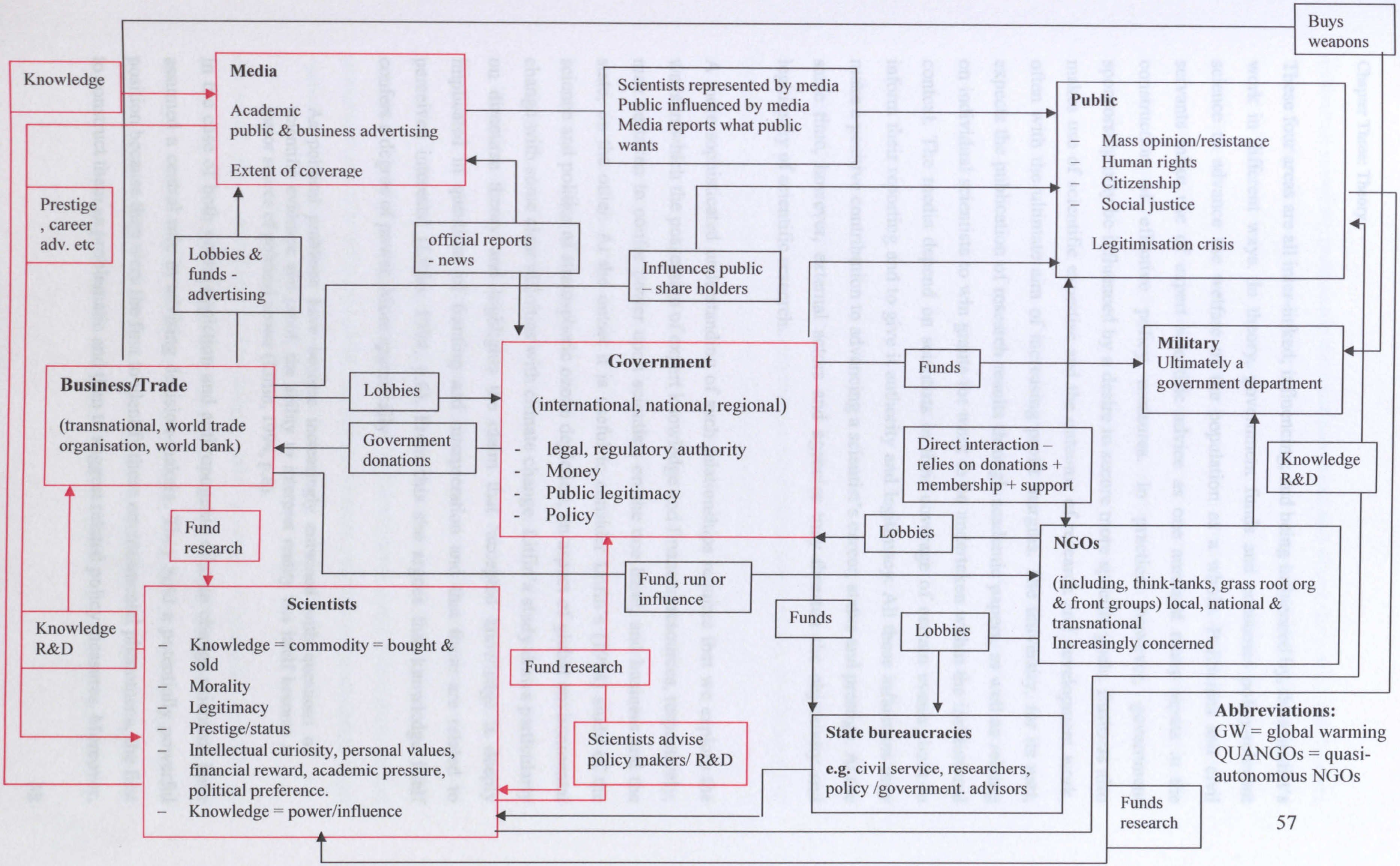
1. The internal academic environment – this is a reflection not only of the individual scientist's interaction with colleagues interested in similar research, but also of the institutional presence of universities and other academic organizations which employ research scientists. As employers, universities may encourage scientists to focus their research in particular areas.

2. The funding received from government, which is often directed towards the development of policy-relevant research.

3. The funding received from private business, usually in the expectation that the research will yield findings of potential commercial value.

4. The media, which may offer fees that contribute to the scientist's personal income, and which offers the scientist public exposure that enhances individual profile and career prospects, but potentially at the risk of this knowledge being misused or misrepresented.

Fig.3.1: A generalised model of scientists interactions in a developed capitalist society.



These four areas are all inter-linked; influencing, and being influenced by, the scientist's work in different ways. In theory, government funds and consumes policy-relevant science to advance the welfare of the population as a whole. Politicians and civil servants make use of expert scientific advice as one amongst many inputs in the construction of effective policy measures. In practice, however, government sponsorship may be influenced by a desire to secure more specific goals. Business also makes use of scientific expertise and the outcome of research and development work, often with the ultimate aim of increasing profit margins. The university, for its part, expects the publication of research results through academic papers, as well as relying on individual scientists to win grants for work to be undertaken within the institutional context. The media depend on scientists in their coverage of certain events, both to inform their reporting and to give it authority and legitimacy. All these influences may make a positive contribution to advancing a scientist's career, status and prestige. At the same time, however, external actors and agencies may threaten the objectivity and legitimacy of scientific research.

A more sophisticated understanding of such relationships requires that we explore the ways in which the possession of expert knowledge and financial resources, respectively, may be taken to confer power upon scientists on the one hand, and business and the state, on the other. At the outset it is useful to consider Litfin's (1994) study of the science and politics of stratospheric ozone depletion, an aspect of global environmental change with some clear affinities with climate change. Litfin's study draws particularly on discourse theory and highlights the claim that 'accepted knowledge is deeply implicated in questions of framing and interpretation and that these are related to perceived interests' (Litfin, 1994, p.6). From this she argues that knowledge itself confers a degree of power. More specifically:

> As political problems have become increasingly entwined with questions of scientific evidence and proof, the ability to interpret reality has itself become a major source of political power (Litfin, 1994, p.8).

In the case of both ozone depletion and anthropogenic climate change scientists have assumed a central role in advising decision-makers. They hold a potentially powerful position because they were the first to identify these environmental phenomena, the first to construct them as problematic and then to suggest related policy measures. Moreover,

individual scientists, particularly the most prominent and senior, may act as gatekeepers of knowledge. Within the scientific realm they exercise considerable control over what is published and what is not, consequently assuming power as influential agents in the production and dissemination of knowledge. Such individuals may also play a leading role in establishing contacts with policy makers. At the same time, however, they must be able to present themselves as legitimate representatives of the wider body of scientific opinion if they are to have credibility as the 'voice' of science.

Such thinking echoes Lukes (1974) who in outlining a two-dimensional view of power stresses the importance of agenda setting; that is both setting the terms of the debate and preventing 'undesirable' issues from getting into the bargaining area. This use of 'tactical' power was refined by Bacharach and Lawler (1980), who highlighted as one aspect the existence of 'expert power'; that is the power of professional experts to influence decisions. In the late 1980s when climate change was becoming more firmly established on the political agenda, it could be argued that climate scientists temporarily succeeded in setting the agenda, requiring a response in shape of the establishment of the IPCC.

As the position of climate scientists within society has changed, giving them greater access to policy makers and potential influence over policy formation (as outlined in the 1987 Brundtland Report: WCED, 1987, p.326; see also Elliott, 1998, p.121) scientists have thus become potentially more influential. Such influence is not, however, beyond challenge. In this respect it is useful to draw a distinction between the present emphasis on the influence of science and Litfin's argument that scientific expertise grants power. Within the politicised climate science debate it is clear that scientists are not all-powerful, but rather that they have a partial influence upon the political process. This echoes Arts' (1998, p.58) characterisation of 'political power [which] is a more or less permanent ability to influence policy outcomes, whereas political influence refers to an episodic effect on decision-making'.

As noted above governments increasingly take account of scientific expertise in considering how to react to the risks associated with potentially dangerous issues such as anthropogenic climate change. Potentially, ignoring such risks could have grave consequences, leading not just to environmental damage, but also to significant economic, social and political disruption. However, more immediate interests may

dictate a less active response to warnings about climate change. This may reflect constraints associated with the third phase of power outlined by Lukes (1974); this is to argue that people's social horizons are limited by underlying assumptions and attitudes that follow from their upbringing, education and the messages received from the media in advanced industrial societies. In the contemporary context most of these attitudes and assumptions are consistent with the continuing operation of a carbon-based economy and the majority of the population finds it correspondingly difficult to conceive of an alternative existence. Such a mind set may, however, be deliberately reinforced by the way in which particular vested interests – particularly private business – attempt to advance their own agenda, which reflects the rejection of any policy responses that appear to threaten short-term curbs on economic growth and profitability.

It would be possible to conceive of debate over climate change policy being conducted in exclusively financial terms, reflecting different interpretations of the costs associated with specific policy responses. In practice, however, both those arguing for and against decisive initiatives to counter climate change have attempted to recruit scientific support for their point of view. This reflects the legitimacy that science as a privileged good in modern western liberal societies is assumed to confer upon an argument. As Barnes (1985, p.100) notes, access to technical expertise is itself a source of power for political and commercial elites as they are able 'to use that expertise both to arrive at decisions, and perhaps even more importantly to legitimate and justify them once made'. If a stance can be presented as the outcome of reflection upon the 'disinterested' opinions and advice of scientists it is less easy to dismiss as a nakedly self-interested argument. Yet the very fact that science can be taken to perform this legitimating role increases the temptation for outside interests to set their own stamp upon the process of production of scientific knowledge. The power of science as expert knowledge is the very reason why it may be subject to attempted subversion, often involving the alternative power conferred upon elite actors by their command of financial resources. It is worth recalling at this point the frequency with which Figure 3.1 identifies funding as a crucial link between science and other actors.

In the present case it is, of course, true that alternative readings of the scientific evidence have their origins in genuine uncertainties about the existence and extent of climate change and its causal mechanisms. However, such differences of interpretation also have implications for the construction of policy responses that will impact on

specific commercial interests, in particular. Thus the charge has been laid that such interests have been motivated to exploit a perpetual hunger on the part of scientists for funding, to sponsor research that clouds or distorts the scientific agenda in ways that serve the sponsor's own sectional ends.

Beder (1997, 1999), amongst others, has alleged that the stance of certain vocal climate sceptics reflects the fact that they have been 'bought' by businesses which have an interest in undermining the legitimacy of concerns about climate change. These scientists are argued to gain substantial financial benefits as a result of advancing a particular scientific stance. As might be expected, the individuals concerned dispute that they are being bought in this crude fashion, or that their research results are influenced by the source of their funding. But it is clearly the case that the sponsorship of particular scientific arguments can advance the interests of important businesses in sectors such as energy and motor vehicle production if it enables them to refute protagonist arguments about climate change.

Ultimately, it seems, scientific expertise is used selectively to meet the interests of political and economic actors, rather than having any consistent power to determine the actions of such actors. Science can be used to justify government resistance to commercial pressures and to legitimate legislation that changes commercial practice. However, policy-makers and powerful commercial interests often reject scientific expertise, or counter scientific arguments that threaten the existing status quo through the sponsorship of alternative scientific viewpoints.

At the same time, it is likely that some leading – and very vocal – climate scientists are well aware not only of the scientific and policy implications of their work, but also of its commercial value and the consequent potential for personal financial benefit. Indeed, this may be a consideration driving their decision to adopt a high public and media profile regarding climate change. If scientific expertise is to be bought and sold it is arguably high-profile scientists who are the most worth 'buying', if the objective is to influence public and political opinion.

3.3 Science as viewed by Political Economy

The discussion so far has served to confirm the identity of the main actors that we need to consider in any attempt to understand the relationships between the science and society. More than this we have begun to sketch out a rationale for engagement between scientific, political and commercial actors that is more complex than that outlined in the initial discussion of Figure 3.1. This is important, for it is the exploration of this rationale and its implications for the conduct and content of science that will be subject to empirical scrutiny in Chapters Five and Six. At the same time, it is evident that new questions have been raised about how we should best understand the logic of the attitudes and actions ascribed to particular actors in our discussion. This in turn points to the need for further theoretical discussion of the nature and functions of our key actors and the ways in which they might be bound together in contemporary capitalist society.

Some of the most sophisticated discussion of the constitution and operations of capitalist society derives from authors and analysts whose ideas have been influenced by Marxist political economy. It seems appropriate here to turn our attention in this direction, not least because Marxist discussions of the nature of capitalism offer arguments concerning the engagement between science and society that provide an important counter-point to ideas of the independence and integrity of science with which we began this chapter. For reasons that will become clear, however, the following discussion deals only briefly with the more determinist Marxist readings of science as an activity wholly subordinate to the interests of the dominant capitalist class. Instead, the focus is on readings of capital, the state and science that are better regarded as neo-Marxist in that they acknowledge the centrality of capitalist interests in contemporary Western societies, without assuming that a base defined in economic terms is the necessary determinant of the nature of societal superstructure. It is a neo-Marxist perspective that seems best to meet our needs for an effective theoretical lens through which to focus the research aims introduced in Chapter One.

3.3.1 Science and the Economic Base

As noted above, the political economy perspective emphasises the relationship between the conduct and content of scientific enquiry and the interests of capitalism. Indeed, it suggests that science is a dimension of the societal superstructure which is necessarily

determined by the economic base (Gamble *et al*, 1999). Under capitalism, therefore, scientific research reflects what is deemed useful knowledge by the dominant capitalist class (Hessen 1971; Rose and Rose 1976). Such a relationship might account for a willingness to invest in the production of certain types of environmental science, both on the part of business itself and by the state as the agent of the capitalist class. Some forms of applied environmental knowledge have the direct potential to generate commercial returns for business; if, for example, they record the existence and properties of natural resources capable of profitable exploitation (see for instance, Wade, 2003). Furthermore, a desire for such applied knowledge may make it worthwhile for capitalist interests to secure the production of some forms of basic environmental scientific knowledge. Basic understanding of the form and functions of environmental systems may, for example, be necessary if applied researchers are to understand the principles which explain the distribution of exploitable reserves of key resources and thus predict their occurrence and value.

However, such a narrow capitalist logic for the funding and production of scientific knowledge seems at odds with the observed diversity of research in contemporary environmental science. Specifically, there appears to be a tension between an overly determinist approach to explaining the conduct of science and the existence of scientific research that seems, at least on the surface, to be opposed to capitalist interests in that it highlights the environmental damage done by economic activity and the pursuit of capital accumulation (Pepper, 1996; Schnaiberg, 1980). Moreover, with respect to climate change, it is difficult to reconcile the evident debate and diversity of opinion in the field with the theoretical assumption of a coherent capitalist interest dictating the course of the production of scientific knowledge. It is important, therefore, to acknowledge the recent re-evaluation by leading Marxist theorists of the apparent certainties of determinist arguments. Often this has involved renewed attention to the subtleties and ambiguities evident in Marx's own writings, which have too often been lost in subsequent analysis (Miller, 1991). Two aspects of this process of review should be highlighted here. The first focuses on the portrayal of science per se, while the second reflects debate about Marxist characterisations of the state.

3.3.2 Towards a Neo-Marxist Perspective on Science

Past research that explores the history and philosophy of science has led the way in arguing that the theory of historical materialism is too reductionist in its portrayal of science (Bunge, 1991; Sohn-Rethel, 1975). Hence Abraham (1995), for example, is clear that some degree of cognitive autonomy should be attributed to science (cf Aronowitz, 1988; Rothman *et al,* 1996; Yudin, 1997). This is not to deny that the drive for capital accumulation has been, and continues to be, an influence upon the development of scientific knowledge. It does not follow, however, that scientists and scientific knowledge in capitalist societies necessarily and exclusively serve capitalist interests. This 'reformist' approach to Marxist studies of the societal position of science can be traced at least as far back as the work of Bernal in the 1930s (see Bernal 1949, pp.334-428, for collection of his writings during this period; see also Bernal 1939). He saw in Marx's writings a belief that science and technology were historically progressive forces. But while they were often used by capitalism to advance its own ends, Bernal argues that Marx ultimately conceived of scientific knowledge as politically neutral. It could thus be directed towards the liberation, rather than the exploitation, of the working class, and might therefore prove to be an anti-capitalist force (Bernal, 1949). There are echoes of such thinking in more recent work on science and society. Stachel (1995), for example, notes that Marx identified historical contexts in which scientific labour was largely independent of any systematic or formal control by capital. On this basis, Stachel argues that the potential exists for the transformation of the current situation in which the work of scientists 'is increasingly organized under the direct control of capital' (Stachel, 1995, p.78). He goes on to claim that such liberation could be achieved by advancing a sense of common cause between intellectual and manual labour in resisting capitalist exploitation. It is not necessary here to engage fully with the content or implications of Stachel's argument. What is relevant is his restatement of the idea that science is not *necessarily* subordinate to the determining control of the economic substructure.

If we follow the argument that science may be conducted to achieve ends other than that of increased capital accumulation this allows us to return to the notion that increased scientific understanding may be pursued as a goal in its own right. Yet this is not simply to repeat the normative conceptions of science reviewed in Section 3.2.1. We should retain the thought that knowledge for knowledge's sake is unlikely to be the only, or

even the dominant, ethos that defines the nature of scientific activity. The discussion above points instead to a case for stepping back more carefully from too close an adherence to dogmatic theory about the character and existence of relations between science and the wider forces of political economy. Rather than providing universal answers to our questions about the nature of science, such theory is perhaps best viewed as raising issues that demand empirical investigation into the nature of the relationships between science and society in particular contexts. Thinking in this way is also consistent with other strands in recent Marxist debate. While the latter focus primarily on the characterisation of the state, they have clear implications for the present concern with science. This is true not least because, as previously noted, the state performs an important role as sponsor and paymaster for scientific activity in most contemporary capitalist societies.

3.3.3 Rethinking the Role of the State

As previously noted, an approach grounded in Marxist political economy presents the modern state as an element of the superstructure, subordinate to the interests of the underlying capitalist base. The state is therefore viewed as an instrument of the ruling class (Plekanov, 1961, see also Gamble *et al*, 1999). On the face of it, this seems consistent with Marx's assertion that 'the executive of the modern State is but a committee for managing the affairs of the whole bourgeoisie' (Marx, 1973, p.69). This latter characterisation of the state need not, however, imply total subordination of the political to the economic. Indeed, a logical argument can be advanced that for the state to perform effectively the role of manager of bourgeois interests attributed to it by Marx, it must enjoy some degree of autonomy from the economic base. This argument stems from an understanding of capital as fundamentally incapable either of reproducing itself, or of securing conditions necessary for its own reproduction. It follows, therefore, that for the continuation of capitalist society there is a need for, or a dependency on, 'managerial intervention'. These interventions, which serve the general, long-term interests of capital, are performed by the state, which is seen to act as 'the ideal collective capitalist'; a characterisation ultimately traceable to the writings of Engels (Hay, 1999, pp.154-55).

This central proposition about the managerial role of the state has inspired considerable, if not wholly productive, debate as to how and why the state discharges this function.

Writing from an instrumentalist perspective, Miliband (1977) argues that the modern state acts as manager in the general interests of capitalism because its theoretical neutrality as an institutional ensemble is overtaken in practice by the ability of the capitalist class to influence the way that the state discharges its functions. In particular, Miliband emphasises the extent to which capitalist interests influence, and in some instances provide, the personnel of the state. The latter are granted considerable importance, for their decisions are deemed to ensure that the state acts in the interests of capitalism (see also McLellan, 1998). By contrast, Poulantzas, especially in his earlier writings on this topic (1974), asserts the causal priority of structures over the agency of individual state managers. Hence, a capitalist economy creates a capitalist state, but one possessed of the necessary relative autonomy to discharge its managerial functions. More recently Block (1987a, 1987b) has advanced a more sophisticated interpretation of the relationship between state managers and the capitalist class. The two, he argues, exhibit a division of labour, but are at the same time linked by a mutual dependency. It is this relationship which ensures the coincidence between the interests of state managers and the long-term collective interests of the capitalist class. It is not simply the case that the capitalist class requires managerial intervention to secure its survival. State managers are just as dependent upon the long-term continuity of capital accumulation, as this provides an essential foundation for the generation of state revenue and, more broadly, for the maintenance of public support for existing policies. State personnel, therefore, work to ensure the long-term continuity and growth of capitalist regimes because ultimately this strategy offers the best means of ensuring their own survival.

Much of the detail of the specific cases advanced by the participants in this debate about the nature of the state is beyond the scope of the present thesis. It is sufficient here to note that they articulate broadly comparable arguments that the state acts as a manager or custodian of the general interests of capital. Crucially, too, they assert that to perform this role, the state must enjoy some degree of autonomy; whether this is considered to be relative (as is the case in the work of Miliband, 1977 and Poulantzas, 1978), or potentially total (as argued by Block, 1987a, 1987b). The case for autonomy stems from a recognition of the likely tensions between actions and decisions that support the immediate pursuit of business opportunity and profit by individual capitalist interests, and those which are necessary to maintain the long-term health and stability of the capitalist system as a whole (Schwarzmantel, 1994). As Miliband (1977, p.88) notes it

may be apparent that 'reform must in the long run be accepted if the social order is to perpetuate itself', yet the impetus for change is blunted by the knowledge that 'the price to be paid in the short run is often real and unpalatable'.

To ensure that such reforms are effectively pursued, and that controversial short-term costs are paid, the state must therefore be endowed with the necessary authority and independence to overcome protest and opposition. Moreover, such opposition should not be assumed to reflect only the grievances of subordinate or marginalised class interests. Miliband (1977, p.88) also suggests that:

> much, if not most, of the reform which power holders have organised in capitalist societies has generally been strongly and even bitterly opposed by one or another faction of the "ruling class", or by most of it.

This tension between specific and general interests, and between long-term and short-term goals would thus appear to explain the observed, yet seemingly paradoxical, discontent of the bourgeoisie with the actions of state systems that ultimately act in their particular interests.

The managerial role of the state has conventionally been defined by its functions, which include the provision of a material infrastructure; a legal system that both defends the rights of private property owners and outlaws practices that work against capital accumulation; and the regulation of conflict between the class interests of capital and labour. The latter, in particular, may involve securing apparent concessions to labour interests – for example, state organised and enforced income redistribution and welfare provision – that in the long-term serve also to meet capitalist interests in the continuation of established economic and social structures. The importance often attributed to the capital-labour relationship in analyses of capitalist economies should not preclude considerations of the relationship between capital and the environment, which may also be characterised by mutual antagonism (Barry, 1999; Gorz, 1987; Hay, 1994; Schnaiberg, 1980).

3.3.4 The Environment, Capital and the State: A Context for the Production of Scientific Knowledge

Consideration of the capital-environment relationship must, firstly, recognise that capital accumulation invariably entails consumption of natural resources and environmental damage (Barry, 1999). This is the most obvious source of opposition between the two interests (Schnaiberg, 1980). Human control over nature is, however, far from absolute. Nature may exhibit the power to 'bite back' in ways that threaten the survival of economic and social systems. Specifically, the exhaustion of natural resources, and mounting pollution and other forms of environmental damage, may undermine the continued profitability and viability of economic development under capitalism (and, it must be acknowledged, under state socialism: Hannigan, 1995, p.22). It follows, therefore, that a key dimension of the managerial function of the state discussed above, should be to attend to the negative environmental impacts of capitalism (Redclift, 1986). This assumes that individual businesses are likely to be reluctant to change their products and behaviour voluntarily in ways that entail obvious and immediate reductions in profitability and competitiveness. As a result it falls to the state to implement environmental protection policies where current practices constitute a direct threat to the long-term survival of economic systems, or where environmental degradation raises the prospect of growing social and political instability, which in turn threatens capitalist accumulation (Barry, 1999).

It is, of course, possible to counter the argument outlined above. Recent years have seen increasing claims that business itself may perform a vital role in defusing environmental problems (Jacobs, 1994). The premise of ecological modernisation theory, for example, is that business-driven technological innovation may deliver new products and processes that yield both commercial and ecological benefits (Mol, 1997). The need for a politically-directed structure of environmental regulation and management is not, therefore, beyond dispute. Accepting that environmental management is a potentially important state function does, however, indicate a logic for state investment in a much broader range of 'useful' scientific knowledge than that implied by reductionist Marxist models of the capitalist state.

Scientific research which catalogues or predicts the extent to which economic activity modifies and damages environmental systems, as is the case with much work on climate

change, indicates the scale of costs generated by economic activity (Mabey *et al*, 1997) (see for example, McCarthy *et al*, 2001 - Contribution of Working Group II to the Third Assessment Report of the IPCC). In so doing it may appear to be working against capitalist interests, particularly if it inspires arguments that such costs should be paid directly by those who cause them, potentially reducing business profits, or that costs should themselves be reduced, even where this involves curbing economic activity and commercial growth (Barry, 1999; Gorz, 1987; Hay 1994). A more considered reading, however, suggests that knowledge of the environmental damage caused by economic activity may actually serve the interests of capitalism in several different ways. Sponsorship of such science may, therefore, be wholly consistent with the role of the modern state as the defender of the long-term survival of capitalism.

Where environmental change and damage are sufficiently extensive, serious and irreversible as to jeopardise future economic growth and social and political stability, it is to the ultimate advantage of capitalism to receive advanced warning of this threat (Barry, 1999; Hay, 1994; Schnaiberg, 1980). Potentially, at least, this allows scope both for reforms to prevent any damage that is not already inevitable, and for strategic planning to enable society to cope better with the consequences of such environmental change that cannot be prevented. It follows that such environmental knowledge, even if it leads to additional economic costs and dislocation in the short term, may be essential to the long-term survival of the capitalist system. Given the role allocated to the state as the ultimate guardian of capitalist interests it is logical that it should sponsor scientific research into the impact of development upon the environment. The state may also permit, even encourage, the sponsorship of such research by other agencies, even those with an immediate agenda that is pro-environmental and anti-capitalist (see for example, the Economic and Social Research Council, 2004).

Other perspectives concerning the state as a collective capitalist appear consistent with the apparent diversity in practice of the science sponsored as useful knowledge. The very need for a managerial state reflects, at least in part, the fragmentation of capitalism into many different interests and competing units. This fragmentation, in turn, makes it likely that there will be no single reading common to all key economic and political actors of what constitutes useful knowledge (see for example, Miliband, 1969, p.51, cf the constructionist perspective advanced in Hannigan, 1995, p.23). Indeed, the existence of sectional and competing interests may lead to sponsorship – both commercial and

political – of competing forms of useful knowledge. This may be evident in disagreement concerning the priority to be attached to particular topics for scientific research. However, in areas where existing scientific knowledge is particularly uncertain or contentious, and where such scientific debates have direct implications for specific external interests, it is more than usually likely that this will lead to sponsorship of a range of scientists advancing different interpretations of a single issue.

Superficially, at least, such arguments seem consistent with previous observations regarding the funding and form of environmental science, in general, and work on climate change, in particular. Some sections of capitalism – whether defined in terms of specific industries, or even particular companies – may perceive it to be in their immediate interest to reinforce the logic outlined above for state sponsorship of scientific research that highlights potential environmental degradation (Barry, 1999; Schnaiberg, 1980). Businesses may, for example, perceive their commercial interests to be particularly vulnerable to specific environmental changes. For example, coastal fishing interests may be anxious to know more about the threat that estuarine industrial pollution may present to the future value of their fishing grounds (see, for example, Academy of Natural Sciences' Estuarine Research Centre, 2002). In the present case of climate change, the insurance industry has particular cause for concern about its profitability and financial security as these may be undermined by a growing level of claims resulting from damage to life and property caused by climatic instability (Paterson, 1999). One line of defence against such difficulties may be the promotion of scientific research to clarify the reality and scale of the environmental threat.

By contrast some commercial interests may regard specific aspects of environmental damage or change as creating new and profitable opportunities. It is apparent, for example, that the production and installation of equipment to detect, reduce, or prevent pollution has itself become a lucrative business. Again this is evident with respect to climate change. On the one hand there is money to be made in developing and supplying energy management systems and energy-efficient equipment. On the other, concerns about climate change seem likely to transform the economics of renewable and emission-free energy production (Rowlands, 2000). Such is the potential for profitable new business that some commentators (such as Boehmer-Christiansen, 1994a, 1994b; Morris, 1997) have suggested that vested interests may even sponsor science that is

'useful' in that it misrepresents the causes of climate change, or overstates its likely scale and implications.

The argument so far has shown that it is possible to outline a capitalist logic for the sponsorship of science that documents the damage inflicted upon the environment by economic activity; that seeks to clarify the precise causes of this damage; that makes an informed projection of the future extent and consequences of damage; and that provides a basis for reform initiatives intended to minimise the negative feedback upon human systems and thus secure the conditions for continued capital accumulation. Yet the very existence of such science and its potential use in reform policy may in turn inspire other sectional interests within capitalism to become involved with environmental issues. This may be particularly evident in the case of those interests and industries which see in the proposed environmental reform policies a major and immediate threat to their own specific profitability and livelihood. 'Polluter pays' policies, for example, may be an effective means of curbing environmental damage (Jacobs, 1993) that would otherwise interfere with long-term prospects for economic growth (Mabey *et al*, 1997). In the short term, however, it is often perceived to impose additional costs on particular businesses.

Policy action against climate change could affect business activity in general through impacts such as higher energy costs. Changes in the energy market are, however, likely to have particularly adverse effects on the short-term fortunes of specific sectors, including energy-intensive heavy industry, the producers of carbon-based energy and motor vehicle manufacturers (Barry, 1999; Hay, 1994). Hence it is unsurprising that leading businesses from these sectors have been active in promoting arguments opposing immediate or radical action against climate change. Such activity involves direct political lobbying, both at a national and international level, in an effort to block the definition and implementation of climate change policy. But energy-related commercial interests have also emerged as sponsors of climate science. Often, critics allege (for example, Beder 1997, 1999), this is sponsorship with a particular goal in mind; to promote the production of knowledge that will discredit or cast doubt upon prior scientific arguments regarding the existence, causation and the extent of the detrimental effects of climate change (cf Evans and Packham, 2003; Monbiot 2003; Pritchard, 1996; Williams, 1996).

The short-term commercial interests of the energy lobby are clearly served by arguments either that the anthropogenic component of climate change is small , or that any climate change which does occur is beneficial (see, for example, Burt, 2003). More specifically, however, it is important that such arguments are seen to have scientific foundations (see Chapter Two). The legitimacy that society habitually accords to knowledge deemed 'scientific' has been important to the energy lobby in its efforts to gain support for its stance on climate change (Beder, 1997, 1999; Lubbers, 2002; Rowell, 1996). Mere assertion that the problem of climate change has been exaggerated would constitute only a weak foundation from which to launch an attempt to influence state policy. By comparison, the presentation of such an argument as a scientific 'truth' seems much more likely to be credible (Pepper, 1996).

The attempt by sectional – and sometimes opposed – groups to buy scientific knowledge suggests a paradox in relations between science and society. The sponsorship of science in support of a particular interest group is often desired precisely because of the apparent legitimacy it confers upon the stance and actions of the group. Yet the very act of selective up-take and sponsorship of particular strands of scientific knowledge – and particular perspectives upon contentious issues – seems at odds with the notion of a singular scientific 'truth'. Moreover, the explicit recruitment of science by identifiable interests exposes the fragility of claims for a privileged position for science as the independent purveyor of proven knowledge.

3.4 Conclusions and Implications

By conceding greater autonomy to the state than more reductionist interpretations of Marxist political economy would allow and by recognising the likely existence of specific sectional interests within capitalism, it is possible to set out a neo-Marxist perspective on the production of scientific knowledge that seems more consistent with the diversity of activity and opinion within the climate change debate. Yet questions remain both about the character of the actors and agencies identified above, and the nature of the relationships that link them together.

Some of these questions are beyond the immediate scope of this thesis, particularly those that relate to the conception of the state advanced above. It is evident, for example, that the assumption that the state acts as the guardian of the long-term interests

of capitalism appears to attribute to the state a considerable degree of foreknowledge. Yet it is not clear how the state arrives at this particular ability to know the interests of capitalism better than do capitalists themselves. Perhaps this serves to reinforce the case just advanced for the importance of scientists – and other 'experts' – as predictors of future threats of socio-economic instability. At the same time, a case such as climate change reveals the extent to which long-term management strategies may be disputed, not simply by economic interests, but also within the framework of state institutions. There is no political consensus about the policy measures necessary to combat climate change as a threat to the continuity of capitalism. A change of political personnel, as involved in a change of government, may therefore lead to significant policy shifts that have no basis in any revision of scientific opinion.

Moreover, the idea that the state focuses on securing the long-term seems at odds with the limited time horizons that inform most decisions taken by individual governments. An international perspective also reveals the extent to which state authorities differ in their stance towards an issue which is necessarily global (see for example, Carter, 2001, pp224-253; Faure *et al*, 2003, pp320-321). Is it possible that different policy stances – such as are currently being pursued by the USA and the UK – are all somehow working to protect the long-term interests of capitalism?

If there are doubts about this issue, this places a larger question mark over the characterisation of the state in the neo-Marxist accounts discussed above. Is it necessarily the case that the state performs the role attributed to it of ideal collective capitalist? This is not simply to question whether the state can always execute this role effectively in practice. It also raises the prospect that by intent the state may pursue goals other than the long-term defence of the interests of the bourgeoisie as a class. If we accept this possibility then it opens up the prospect that the state may find other uses in scientific knowledge beyond those outlined above.

This last observation takes the argument back to concerns about the production and consumption of science that are central to the present thesis. The rejection of an idealised notion of science as an independent and value-free realm of activity creates a need for a theoretical framework that will inform the following exploration of the case of climate science. A neo-Marxist approach is favoured here because it retains a view of science as an activity strongly influenced by capitalist interests, without the

reductionism of accounts that attribute ultimate power to a unitary economic base. Rather we have been able to advance a more specific set of arguments as to why both business and the state – as distinct and perhaps diverse interests – should adopt roles as sponsors and consumers of science. In turn, this variety of different sponsors has been invoked as a factor that might help to explain and sustain a diversity of scientific activity and opinion.

It follows that the thesis should seek confirmation of the extent to which the theoretical logic for funding climate science by a range of different interests appears to be borne out in practice. This will involve attention to the sources of research funding available in the two main communities of climate researchers, in the UK and the USA – and to the implications of the relative scale of funding available from different sources with different interests, in influencing the agenda for climate research.

The main focus of what follows is, however, upon the perceptions of scientists themselves regarding their relationships with financial sponsors. As noted above, such relationships are potentially complex. One the one hand we might expect scientists to exhibit some sense of dependency on external funding sources. This can be compared with external perceptions, which have even gone so far as to call into question the legitimacy of some research. Yet the possession of expertise – and attendant influence within academia and academic publishing – arguably also gives scientists themselves a degree of influence upon the research and policy agenda. Associated with this is a role in determining the allocation of future funding. The thesis will therefore explore how this balance between influence and dependency is perceived, attending to potential contrasts between individuals adopting different positions on the science of climate change, those working in different institutional and national contexts, and those with different career and media profiles.

The study of perceptions leads on to questions about behaviour. Are there strategies that scientists adopt in an attempt to defend their autonomy and integrity, whilst maintaining research income and the academic profile of their work? Are different strategies adopted by climate sceptics and protagonists, and how are these regarded by their counterparts in the other 'camp'? Such questions also return to the possible implications of the availability of alternative funding sources. It seems important to explore scientists' awareness of the range of funding available to them and their perceptions regarding the

accessibility and legitimacy of particular sources. This potentially has much to tell us about relationships between sponsors and researchers and the different ways in which they may be constructed in the case of climate sceptics and climate protagonists. Given our expectation of funding from a range of sources it also seems possible that this may itself have implications for scientific freedom. Is there scope for scientists to 'play the system'? Perhaps, for example, by searching amongst the range of potential paymasters for a sympathetic sponsor to fund research that is inspired primarily by the scientist's own intellectual curiosity.

Before proceeding to address such questions the thesis must first introduce the means by which the necessary information will be obtained. As Chapter Four discusses in more detail, the following empirical investigation draws in part upon published records of funding and publication activity. Its primary focus, however, is a series of interviews with climate scientists themselves, and associated social commentators. Only in this way can we gain insights into the perceptions of the central actors in the current investigation.

CHAPTER FOUR

Framework and Strategies for Examining the Practice of UK and US Climate Change Scientists

4.1 Introduction

The theoretical exploration in Chapter Three of potential relationships between science and scientists, on the one hand, and wider economic and political forces, on the other, highlights the need for more detailed empirical exploration of the context in which climate science is produced. Only in this way can we begin to resolve some of the questions raised about the nature of the relationships between science and its political and commercial sponsors, and about the influence that scientists as 'experts' may themselves exert upon the definition of priorities for research and associated funding.

It has previously been argued that ties between science and society rest on a mutual dependency; on the part of science for external funding, and on the part of society for the understanding that innovative science generates (Figure 3.1). Attention to flows of funding and to activity to disseminate scientific information, both through academic publications and via the wider media, will thus feature in the empirical element of the current study. This chapter outlines a methodology that aims to investigate a series of key issues related to research funding and dissemination. We need to know more about the scale of funding devoted to climate science; about the individual sources that provide this funding; about the agendas set by particular funding agencies that inform their support for climate research; about scientists' relationships with funding agencies and their perceptions of the availability of funding; and about the extent to which scientists perceive their academic freedoms to be restricted either by the need to compete for funding, or by pressures to conform to the agenda of external sponsors. At the same time we must explore the potential influence accorded to scientists as experts in an important field of research with profound societal implications. This will involve consideration of the extent to which the course and content of scientific debate is shaped by scientists themselves through decisions made about the publication of particular arguments about climate change, and the ways in which the scientific debate about climate is presented to policy makers and in the mass media. What is attempted here is not, however, a detailed and comprehensive analysis of the framing of climate science

(cf Shackley and Wynne 1995a, 1995b), but rather an approach to specific questions regarding publication as a means of legitimising, or discounting, particular strands of opinion concerning climate change.

The research design adopted here has two major elements. First, the study analysed a range of secondary sources, including articles in academic journals and the broadsheet press, books, official publications, NGO output, World Wide Web material, and television and radio broadcasts. Such material is useful in providing an overview of the subject area, but it also yielded more specific information about the range of potential funding sources for climate science, some indication of the scale of funding that the different sources provide, and the ways in which funding is targeted towards particular research objectives. In addition, the study of published scientific output – both academic and via the wider media – provides an indication of the ways in which the different strands of opinion in the climate debate present their case, the extent to which they are all able and willing to state their argument through conventional scientific channels, and the different claims to expertise and influence over the policy agenda put forward by sceptics and protagonists.

This analysis of existing texts is complemented by the second main element of the study, which employed an interview-based approach to explore the opinions and perceptions of individuals closely involved in the climate debate. After an initial pilot study, a detailed qualitative investigation using in-depth, semi-structured interviews with climate scientists and social commentators with a particular interest in climate and energy issues, was undertaken during the spring and summer of 2000. By interviewing a number of individuals it was possible to explore something of the range of opinions, attitudes and motivations current amongst climate scientists. Discussions with social commentators added a further dimension, revealing the opinion of informed outsiders about the constitution and practice of the climate science community and the nature of debate about climate change itself. The results of these interviews and the accompanying analysis are presented in Chapters Five and Six.

As a deductive thesis the theoretical perspective developed in the preceding chapter was fundamental to this methodology (and the thesis as a whole). As King *et al* (1994, p.29) point out:

> No empirical investigation can be successful without a theory to guide its choice of questions. Theory and data collection are both essential aspects of the process by which we seek to decide whether a theory should be provisionally viewed true or false.

The theoretical discussion outlined in Chapter Three helped to inform the basis of the empirical evidence by contributing to the formation of the interview questions. The research results are then used not only to report on the state of climate science, but also in an evaluation of the adequacy of the initial theoretical position (May, 1995, p.22).

The current chapter provides a description and justification of the methods used throughout the thesis. Section 4.2 outlines the broad methodological strategies adopted here, involving an emphasis on qualitative methods – specifically the use of semi-structured interviews. This section also offers some observations upon the likely validity of the material obtained in this fashion and the need for cross-comparison with other sources as a means of increasing confidence in the outcome. Sections 4.3 and 4.4 provide a more detailed commentary on the process of identifying suitable interviewees and the construction and administration of the interview schedule. Section 4.5 details the analytical procedures employed in the collation and interrogation of the interview material. Section 4.6 draws the chapter to a conclusion.

4.2 Methodological Strategies: Justifying the Methodology

4.2.1 Implications of Thesis Aims

The methodological framework adopted for this project reflects the specific need to gain insights into the experiences and perceptions of climate change scientists working in two of the major global research clusters in the USA and the UK. Much of the research thus rests on the adoption of a format which provides individual scientists with freedom to talk quite openly about their individual experiences and perceptions. However, the overall needs of the project are served only if contacts with individuals form part of a carefully structured series so that the project engages with actors holding a range of different scientific positions on climate change, and, indeed, political opinions about associated policy. A degree of comparability in the format of individual interviews is also necessary to enable informed and critical scrutiny of the ideas and opinions raised, not only between interviewees, but also with material derived from published sources.

4.2.2 Why Qualitative Analysis?

The value of adopting a methodology that rests primarily on qualitative foundations is confirmed both by an initial review of other studies which seek similar insights into the experiences and perceptions of individual respondents (see, for example, Baxter and Eyles, 1999; Drake *et al*, 2001; Lahsen, 1998; Newall, 2000; Phyne, 1999; Shackley *et al*, 1998; Rothman *et al*, 1996) and by wider discussion in the literature on research methods (for example, Gask *et al*, 2003; Lahikainem *et al*, 2003; Meehan *et al*, 2000). As May (1995, p.91) notes, qualitative research can generate rich data sources regarding 'people's experiences, opinions, aspirations and feelings'. By comparison, it seems unlikely that any quantitative methodology could 'adequately describe or interpret' the 'complex and dynamic' world of climate scientists (Hoepfl, 1997, p.3; see also Hare *et al*, 1978). The use of qualitative techniques offers the prospect of obtaining data that are 'typically rich with detail and insights into participant's experiences of the world, and may be epistemologically in harmony with the reader's experience' (Stake, 1978, p.5). Such an approach is particularly useful here if it can be used successfully to encourage individual scientists and commentators to offer accounts of their own behaviour – and that of other scientists – in specific contexts (cf Hoepfl, 1997). These accounts may usefully be considered in relation to the production and reproduction of larger discourses about the nature of science and its relationship with society. The present thesis itself, however, does not engage in the more detailed textual analysis associated with discourse theory (cf Gee, 1999; Potter, 1997; cf reflexive constructionist discursive studies of scientists' accounts Gilbert and Mulkay, 1984; Mulkay *et al*, 1983)

Qualitative approaches embrace many different techniques, all of which have the potential to generate a mass of interpretative information, including opinions, values and individual insights. This initial choice must, therefore, be followed by efforts to identify the specific techniques that are most appropriate here.

4.2.3 Why Semi-Structured Interviews?

Given the focus of the present research on the ideas and opinions of individual scientists it seems appropriate to employ interviews as the principal means of obtaining qualitative information. This format seems likely to achieve the desired end of encouraging interviewees to offer detailed accounts and opinions without any undue

feelings of constraint – as might arise in focus group exercises. Interviews also allow the researcher to probe for more information as specific themes arise and to invite respondents to expand on any initial accounts offered (Correia and Wilson, 1997). This focus on the individual is, of course, something of a two-edged sword. Care must be taken in constructing any general case or explanation based on narratives that are valid only for the particular actor being questioned (Walker, 1985). An intensive, interview-based approach also sets limits on the number of participants that can be included in any study, typically shifting attention to a small number of key individuals.

Some of these potential difficulties can be overcome by care in the way that interviewees are selected, and in the comparative analysis of material derived from individual interviews, often – as in the present case – within a wider context of ideas and information derived from other sources (see section 4.2.4). To facilitate this process of comparison a degree of standardisation in the interview proceedings is required. The adoption of a semi-formal interview structure is also consistent with the present study's aim of interrogating key theoretical positions through the use of interview material (Fielding, 1988). At the same time it is important not to lose completely the flexibility of the interview format which allows respondents both the freedom to challenge ideas put to them and to raise themes that reflect their own individual perceptions and values (May, 1995). This desire for some measure of both consistency and flexibility points to the use of semi-structured interviews as a primary means of data collection here. This would allow for a common agenda to be discussed with all respondents – informed by the theory outlined in Chapter Three – while retaining the flexibility necessary to enable adaptation to individual circumstances and to allow discussion to pursue unexpected paths and cues (Correia and Wilson, 1997).

4.2.4 Data Quality and Reliability

The facility for comparative analysis offered by a series of semi-structured interviews also reinforces their value as evidence in any investigation. On the one hand such analysis makes it possible to distinguish between aspects of the accounts and opinions offered that are specific to particular individuals and those which reflect shared discourses and underlying factors in common. At the same time such comparisons allow the researcher to assess the degree of confidence which should be placed in material derived from individual sources, whether judged as a record of specific events (such as

the scale of funding awarded to particular scientists to support their research) or as an account of individual behaviour (in relation, for example, to strategies adopted to secure research income). Other studies have highlighted the importance of obtaining and comparing the perspective of different individual actors within a single context. Within a specific organisational hierarchy this may involve a research methodology that exposes a vertical cross-section, with data being obtained from investigation at each hierarchical level (for example, Leonard-Barton, 1990). As discussed below, considerations which relate to the position of individuals within the institutional hierarchy of academia have some potential relevance in the present case; but the primary concern is with obtaining and comparing the perspectives of scientists with a range of different opinions on climate change.

In many instances it is also valuable to set the perspectives of 'insiders' against those of informed external commentators. Hence, the extension of the constituency of interviewees to include selected non-scientists with a particular interest in the field of climate change. The process of comparison and evaluation can also usefully incorporate a range of secondary material, including the media coverage, web sources and publications from government agencies and NGOs noted in Section 4.1. This extension of triangulation to incorporate data from different sources and settings is thus fundamental to the present thesis in helping not only to contextualise, but also to interrogate and evaluate the interview material (cf Baxter and Eyles 1997; Cano, 2003; Cousins, 2000; Trochim, 2003). It may prove valuable, for example, to set climate scientists' assertions about the availability and distribution of research funding against the published record of the sums devoted to climate-related topics by the principal funding organisations. Similarly, any suggestions of bias in the dissemination of particular scientific viewpoints can usefully be tested by an examination of the actual record of publication by key researchers.

Secondary sources themselves should also be subjected to critical scrutiny. Questions about special pleading and the selective use of evidence that are raised by analysis of interview material apply with equal force to written material and secondary sources. It is important to consider the position of the 'author' of any document (or interview), its intended purpose and audience, and the likelihood of biases and omissions. The identification of these individual traits is almost certain to be assisted by comparison of a series of different sources and perspectives.

The intention in all such instances is not, however, simply to establish who is, and is not, a valid or reliable witness in the sense that their account is consistent with information derived from other sources (cf Hammersley, 1990, 1992; Silverman, 1997). It is, of course, important to be able to distinguish as clearly as possible between those accounts that offer credible accounts of individual behaviour – by the interviewee and others – and those which offer only unsubstantiated assertions. This is particularly the case in the present context where we are potentially dealing with behaviour – actual or imagined – that is seen as bad practice when set against an idealised conception of scientific practice. It should be remembered that assertions of bad practice made by individual interviewees do not, of themselves, constitute evidence that such malpractice has taken place. Ultimately, however, where comparisons reveal discrepancies between the accounts offered by individual sources the aim here is not so much to discover which account is 'correct', but to clarify the extend of any such differences between accounts and to explore why these might arise.

4.2.5 Dealing with Output

Semi-structured interviews necessarily produce a large quantity of data. To manage the research results and ensure that important information is not missed or misheard it is standard practice for interviews to be recorded on tape and subsequently transcribed to produce a full written record. Thorough transcription involves checking and re-checking the recorded material against the written text to ensure that none of the information is inaccurately written down. The full output can then be edited so that the answers given by interviewees are coherent – so long as this does not distort the impression given in the aural record.

This process yields a large quantity of data in a semi-structured format, which, therefore, requires further organisation. This can be achieved by a process of categorisation, which will facilitate comparisons both between individual data sources themselves, and with the broader theoretical structure of the thesis. Given the overall aim of understanding the practice and perceptions of US and UK climate scientists attention was focused on themes emerging from the interviews which had a particular bearing on individual's thoughts, opinions, motivations, perceptions and reasons for action. It was also deemed important to cross-tabulate such material with information

about scientist's individual social identities. This points to the need for an analytical method that can not only handle the mass of available information, but also begin to make sense of it. In the present case it is important not to lose the uniqueness of the individual accounts offered by interviewees, while at the same time arranging the data so that they can be used to address the questions raised earlier in the thesis.

Two principal means of analysis are currently in common use; one involving the manual categorisation and interrogation of data, the other achieving similar ends with the aid of a specific computer package. The former can be a laborious option. Hence, the choice was made to use the NUDist (Non-numerical Unstructured Data, Indexing, Sorting and Theorising) software programme as a tool to speed up the process of data analysis (for further details see Section 4.5).

4.3 Implementing the Methodology: Selecting an Interview Sample

Research fields such as climate science, where multiple actors work within a single area, are characterised by considerable heterogeneity amongst their sub-disciplines. This presents a considerable challenge to any attempt to structure a study to examine their practice and relationships. As Smith (1996, p.201) points out:

> individuals in groups inevitably coalesce into subgroups, which invalidates the sense of homogeneity suggested by the term "scientists" or "scientific community" … there is no single scientific world, even with a field of study, let alone across disciplines.

Galison (1997, p.782) also notes that individual scientific disciplines, as well as specialities within them, are inherently disunited to the extent that practitioners of a single discipline or sub-discipline 'cannot be considered homogeneous communities'. Pinch (1981, p.132) concludes, therefore, that 'the inherent messiness of … sociological research is due to the meshing of different fields and specialities'.

It is indeed the case that scientific investigation of climate change is undertaken by a diverse group of researchers with different geographical backgrounds, specialities and disciplinary affiliations. They include meteorologists, mathematicians, physicists, chemists, oceanographers and biologists. Each field divides into a number of sub-disciplines and specialities, and the complexity is compounded by the existence of cross-disciplinary groupings. It is not entirely clear, moreover, where the external

boundaries of this population should be drawn. Social scientists, such as economists, whose primary concern is with the human implications of climate change do not form part of the present study. But there are, for example, some individual natural scientists who have made significant, if occasional, contributions to the climate change debate whose primary research interests are far removed from climate per se. This problem of defining the population from which a sample of interviewees should be drawn adds to the challenge of selecting individuals who will provide a cross-section of attitudes and opinions that is as representative as possible.

4.3.1 Categorising Scientists and Selecting an Interview Sample

It was evident from the outset that interviewing climate scientists from both the UK and the USA would provide interesting contextual differences. A trans-Atlantic perspective would provide comparisons between the effects that commercial and governmental forces have upon the production of knowledge in two key scientific arenas, which are also states with a recognisably different stance on climate change policy. Although the two countries broadly share a tradition of free-market capitalism and liberal democracy, there are some significant differences of detail, not least with respect to the role accorded to the state. The review of previous studies in Chapter Two (Boehmer-Christiansen 1994a and 1994b; Hart and Victor 1993; Paterson 1996a) acknowledged the potential differences between the practice of scientists in these two western capitalist countries. The potential pressure for climate scientists to gain research funding and publish work may vary, reflecting differences in the university systems between the UK, where the sector is state supported, and the USA, where there are many more private institutions. The USA is also characterised by an apparently greater interest in climate research on the part of fossil fuel producers, and business groups and think-tanks. This could have a particular effect on the practice of some US climate scientists. It might offer one explanation as to why there are more climate 'sceptics' in the USA. It also has a bearing on the US government's decision not to ratify the Kyoto Protocol. These distinctions within and between the two national populations of scientists need to be addressed when selecting interviewees.

To achieve a representative study further distinctions within the scientific population need to be considered. Beder (1997, 1999) singles out climate sceptics as actors within the wider debate who have been 'purchased' by fossil fuel companies to promote a position on global warming that serves many business interests. By contrast, Boehmer-

Christiansen (1994a and 1994b, 1997) argues that climate protagonists amongst the researchers involved with the IPCC have been guilty of compromising their scientific integrity in the pursuit of funding (see Section 2.5.1). It can be seen, therefore, that controversy over climate change is frequently presented as being conducted between two principal scientific camps: the protagonists and the sceptics, or contrarians. As Boehmer-Christiansen and Beder note, the names themselves are considered by some to suggest certain alliances or motivations. Thus, the interviewees need to be selected to represent both of these prominent opposing groups. Although the apparent polarity of opinion is undoubtedly an oversimplification, it nevertheless provides a useful organisational device.

The acknowledgement of a two-fold division should not, however, be taken to suggest that there are equal numbers of protagonists and sceptics. In practice, the sceptics are the smaller group; a fact which itself merits further exploration. It is apparent that contrarianism is frequently evident in scientific areas characterised by considerable uncertainties. An alternative view of the wide range of scientific and political opinions within the climate debate is provided by Glantz (1988). His account of the debate about climate change distinguishes three groups of climate scientists, which he refers to as hawks, owls and doves. Hawks are those scientists who believe that anthropogenic climate change is underway; doves believe that global warming is a scare scenario which will fail to materialise; and owls are undecided about the issue. Yet simply dividing scientists in this way disguises the fact that particular individuals might support or oppose the theory of anthropogenic climate change for different reasons. Each grouping potentially includes individuals whose perspectives on the condition of the environment and the links between human and environmental systems may be rather different.

This study will also take into consideration the career stage and status of the interviewees. One simple measure of this is to distinguish between professorial and non-professorial interviewees – that is between full professors and other faculty members in the US context. Traditionally, this distinction has also had age implications, as professors are generally older and more advanced in their careers. Given the increasing number of younger professors, this generalisation may no longer hold good. Yet professorial status remains a useful way of distinguishing between more and less established scientists. The importance of such distinctions may be reflected in

considerations such as whether interviewees in the early years of their careers feel more pressured to obtain funding to 'climb the career ladder'. Professors, by comparison, may feel sufficiently well established to overcome such pressures; perhaps leading to more candid responses in the interviews. At the same time, however, established scientists may have a greater degree of commitment to the status quo and consequently offer defensive responses to the interviewer.

As suggested when discussing the value of a trans-Atlantic comparison, the institutional context within which an interviewee is employed will also be considered. It is important to identify whether actors working in different types of government and academic institutions perceive different pressures and opportunities when it comes to securing funding for research and disseminating their findings through publication. It might also be the case that climate scientists working within government institutions will be more influential within the political landscape, because they are closer to government figures and policy makers. Thus, climate scientists working in the UK Meteorological Office at the Hadley Centre will be incorporated into this study. It must be acknowledged, however, that time and resources do not permit the present study to provide a detailed review of all potential institutional contexts. For example, interviews with scientists employed by the commercial sector might have provided an interesting contrast to the material included here. It does appear, however, that this would be a numerically small group, as climate scientists are generally only employed by companies to undertake specific research contracts, rather than being permanent staff members.

The suggestion that certain societal interests may purchase vocal scientists to promote specific arguments raises the possibility that a scientist's involvement with the media may affect their funding, personal income, opinions and influence. Consequently, some further divisions need to be introduced into the interview sample. These reflect, firstly, the extent to which individual scientists are involved with the media, and, secondly, the extent to which they are prepared to voice controversial opinions. Such considerations will make it possible to investigate the motives which lead some individuals to become involved with the media. Potential motives range from a sense of genuine concern about climate change and a consequent feeling of duty to inform the public, to a desire for personal prestige. It is also possible that the media itself courts the involvement of scientists prepared to voice contentious opinions.

The divisions outlined above formed the framework for the construction of a list of potential interviewees. Figures 4.1 and 4.2 highlight these factors in organisational terms, such as trans-Atlantic position and stance on climate change. The gaps in some elements of the matrix, particularly for UK sceptics, reflect the difficulty of identifying individuals who fulfil these criteria; which is, of itself, revealing. Sorting the interviewees in this way clearly identifies the range of individuals who would ideally be contacted to produce a broadly representative study of climate change scientists.

Other divisions within the interview sample were also considered, including salary as a reflection of career stage, and gender. The former was ruled out because of difficulties in obtaining such information. While gender is significant, climate change scientists are overwhelmingly male, thus making it particularly difficult to identify female interviewees. Contact was made with one potential female interviewee, but it proved impossible to arrange an interview at a mutually convenient time. Further details about how the interviews were contacted are given in Section 4.4.

4.3.2 Selecting Social Commentators

As noted above, it was recognised that the value of interviews with scientists might be enhanced by a parallel series of contacts with social commentators, who would be able to provide informed, but external, perspectives on the climate debate and the practice of climate change scientists. This constituency of commentators was defined as those individuals who had written extensively about climate science and scientists. In line with the system of categorisation adopted for scientists themselves, interviewees were selected from amongst social scientists and other commentators so as to reflect a range of opinions sympathetic to both climate protagonists and sceptics. The trans-Atlantic dimension of the research was also preserved. This partly reflected a feeling that commentators from the USA and the UK would be best equipped to discuss the practice of scientists working in their own respective countries, but was also born of a desire to explore potentially important national contrasts in the wider context of discussion of climate change. Given the role of social commentators within the thesis research design, as a source of contextual information and opinion, rather than a primary focus of investigation, the number of interviews sought was small. In total three social commentators from the USA were interviewed, together with two from the UK (Fig. 4.3).

Fig. 4.1: Division of Protagonist Scientists

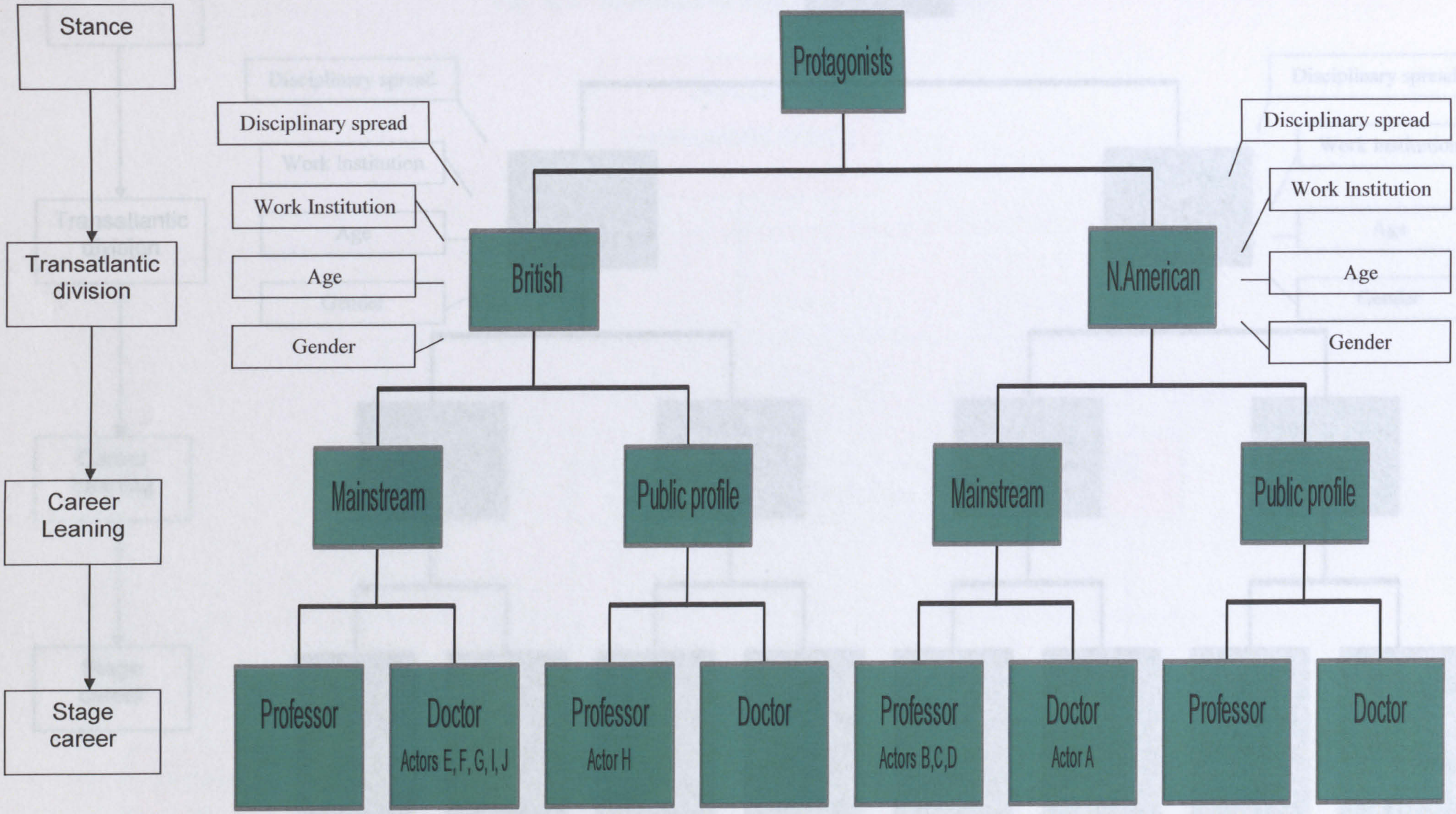


Fig.4.2: Division of Contrarian Climate Change Scientists

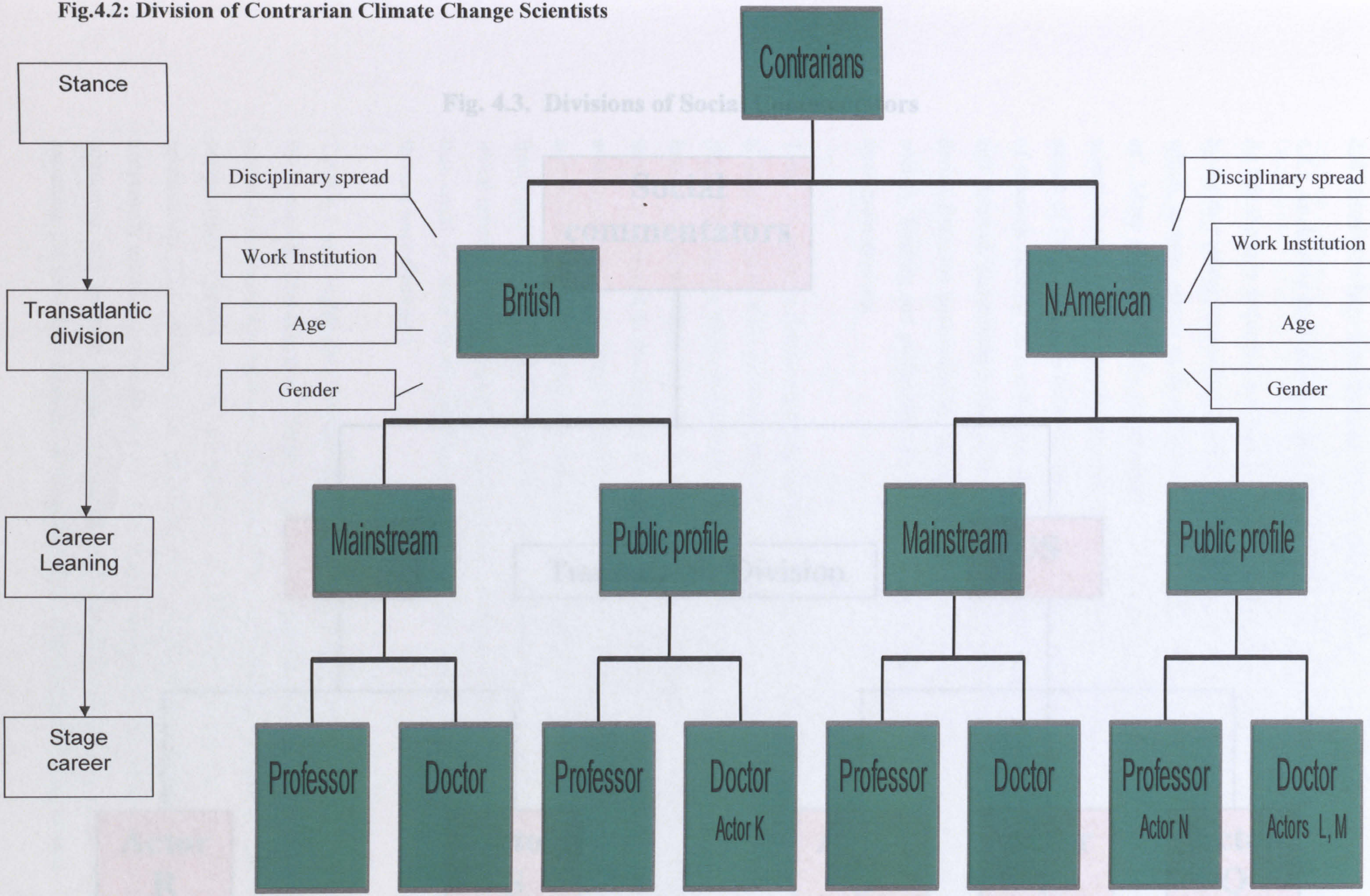
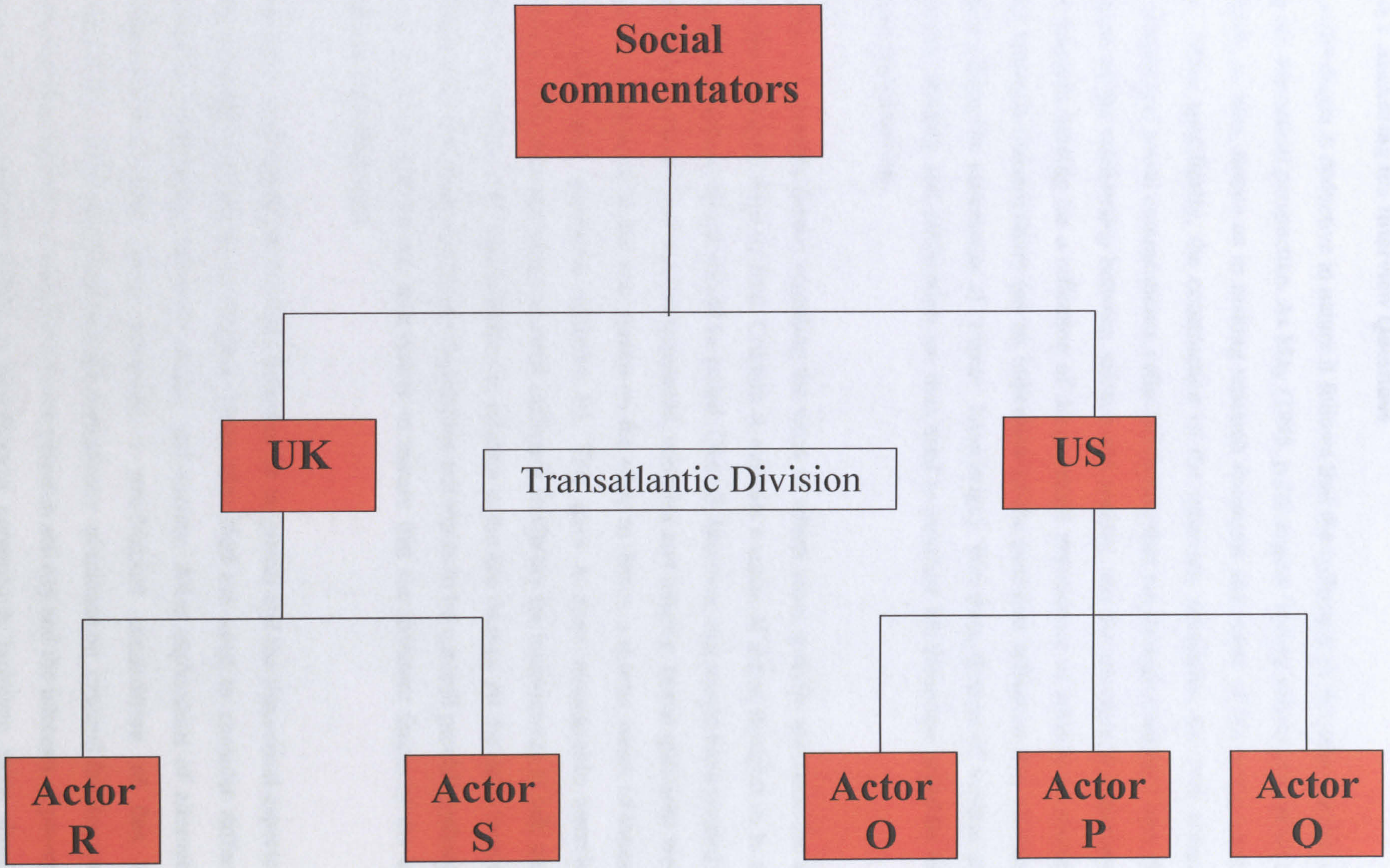


Fig. 4.3. Divisions of Social Commentators



4.4 Interviewing: Qualitative Methods in Action

4.4.1 Anchoring the Interview Questions

As this thesis is deductive in nature it follows that the collection of the data was driven by the theoretical perspective. As May (1995, p.20) argues 'theory informs our thinking which, in turn, assists us in making research decisions and sense of the world around us'. More specifically, the construction of the interview schedules, for both climate scientists and social commentators, reflected themes that run through Chapter Three: the nature of the relationship between science and society, and the consequent importance of research funding (as a reflection of the potential dependence of science on society) and research dissemination (as an indication of the potential influence that scientists derive from the possession of 'expert' knowledge). The three themes of science and society, funding and publication are thus used to structure the interview schedule into three main sections.

Table 4.1 presents details regarding the ways in which some specific questions for the climate scientists were derived. Column A outlines a series of initial thoughts as to the range of questions which should be posed. Overall, however, this would have created an interview schedule that was too structured, complex and lengthy. Initial questions were, therefore, grouped in the way shown on the table to derive a shorter series of broader and open-ended questions (Column B). This gave a more manageable interview schedule and also one which allowed sufficient flexibility for interviewees to talk more freely and define their own priorities in relation to the key themes. At the same time the initial reflection about the range of questions and topics to be covered provided prompts that could be used by the interviewer to ensure that the different facets of the key themes were discussed.

Table 4.1 also highlights the links between the empirical and the theoretical aspects of the research. Discussion in Chapter Three identified the need to consider different potential relationships between science and society. After exploration of alternative perspectives Chapter Three advanced a neo-Marxist construction of this key relationship. This recognises that the dependency of science on external funding must necessarily establish connections between research activity and the interests of powerful economic and political actors. A neo-Marxist perspective, however, stops short of assuming the total determination of scientific activity by external funding sources. This

points to the need to know more about the relationship between scientists and potential funding sources in specific circumstances. We need to explore further scientists' own perceptions regarding the availability of funding for particular forms of research; the extent to which they feel pressured to obtain research funding; the strategies adopted in the search for funding; and the potential implications of competition for funding on academic freedoms and objectivity. Pursuit of these more specific questions should yield both empirically interesting information about the practice of climate scientists, but also help to test the broader validity of a neo-Marxist stance on the issue of science and society.

Table 4.1: The derivation of interview questions: selected example

Column A **Initial questions**	Column B **Interview questions**	Column C **Related theoretical perspective**	Column D **Implication of question in relation to theory**	Column E **Thesis Aims**
Who funds/has funded your research? Are there particular reasons why you have established a relationship with this/these specific body/bodies? Do you think that the funding awarded to you reflects any specific motives/ expectations on the part of the funding body? Are there other bodies that might fund your research for different reasons? Do the attitudes/ expectations of the sponsor affect the way you conduct your research?	**Question 14*** The funding process of research…could you tell me whether your present research was specifically developed for the research grant you received, or did you approach a number of bodies? Which research bodies fund/have funded you? Do these bodies only fund this type of research?	Q aims to address issues regarding the dependence of scientists on external funding that derives ultimately from the economic substructure – but it implicitly retains a recognition of the potential for funding being forthcoming from different sources for different reasons – leading to different types of research being sponsored. If this is perceived to be the case does it confer choices upon scientists about the way that they conduct their research and the type of funding which they accept?	Q should yield insights into perceptions of the differences in motivation that prompt sponsorship of scientific research by specific economic and political actors. Also related to important questions about scientists' perceptions of dependency on specific funding sources – and its implications for the conduct of their research – as opposed to a potential for greater autonomy that might follow from the availability of funding from a range of sources inspired by different motives. How do perceptions of dependency and autonomy vary in particular circumstances?	What accounts of the funding process are offered by individual scientists? How aware are individuals of the funding available from different sources? What accounts do scientists offer of the influence that funding bodies have upon the practice and content of climate change science?

*** Refers to section of interview proceedings**

Prior theoretical discussion also points to the need to consider not only the scale of external funding for research, but the range of sources from which it derives and the potential differences in motivation which prompt specific economic and political actors to sponsor scientific work. Neo-Marxism moves beyond a reductionist assumption that all activity within a capitalist society is ultimately determined by a single 'substructure'. Rather it outlines a logic for difference in the specific interests and functions of the political realm of the state as against the commercial realm of business. By extension, business and the state may have different motives for investing in scientific research, and may be interested in sponsoring different sorts of science, or scientists with differing perspectives upon contentious and policy-relevant issues. Indeed, in cases such as climate science there is both a theoretical and an empirical basis on which to suggest that specific branches of business, or arms of government, may have their own individual agenda, which may be reflected in sponsorship of a contrasting range of scientific projects. Again this needs further exploration, both to confirm the extent to which expectations about this diversity of interests and initiatives are borne out in practice, and to identify its potential implications for scientific practice. This requires that the interview schedule encourages discussion of scientists' perceptions of the range of funding sources available to them, and the extent to which specific sources are identified as promoting a particular agenda with respect to climate change. Discussion might then be taken further to consider the potential implications of diversity in the interests of sponsors of climate change research. Does diversity, for example, encourage perceptions of relative academic freedom amongst scientists if they can 'play the system' to find a sympathetic sponsor for their research? Or is the end result perceived to be the channelling of scientific initiative down a limited number of routes that reflect the interests of the most powerful and generous sponsors?

Examination of these relationships between science and society also requires that consideration be given to the potential influence of scientists themselves upon the agenda for research and funding. Some measure of the role played by scientists can be derived from their success in disseminating their research findings, both within and beyond the academic sphere. Involvement in policy-related initiatives is also a potential indicator of scientific influence. But it is also valuable to use the interviews to explore scientists' perceptions regarding their wider role. Do interviewees feel that they, as individuals, or as part of a larger constituency of scientists, are able to influence the scale of funding for climate science and the specific ends to which it is devoted? And to

what extent do they feel that they possess an 'expert' status which confers influence in shaping the policy response to climate change?

In many instances these are not questions that would be likely to obtain a particularly forthcoming answer if they were posed directly. This reinforces the logic of the approach outlined above of constructing an interview schedule based on a limited number of broadly-defined questions that can be used as the starting point for a semi-structured discussion that can be guided using the interviewer's more detailed – and theoretically informed – agenda. In practice, it was decided that the interviews should begin with opening questions that did not directly address the specific themes of the research. Rather interviewees were asked to introduce their own research area. This strategy was designed to put interviewees at their ease, but it also had the aim of soliciting potentially useful contextual information about the state of climate change science and the context within which scientists operated. The interview then proceeded in a more structured fashion to address the themes of science and society, funding and dissemination. Potentially contentious or threatening issues were raised towards the end of the interview, in the hope that some rapport would have been established between the parties by this stage. The specific content of each interview was different in detail, reflecting both the interests of individual interviewees, and the use of information derived from earlier interviews to stimulate discussion in later sessions. Interview questions were also modified as appropriate in the different national contexts of the USA and the UK.

The schedule used for interviews with social commentators followed a broadly similar structure, although, of course, much of the focus of discussion shifted from the interviewee's own scientific research to their perceptions of the way in which science was conducted. Each interview with an external commentator did, however, include attention to their own writings on science and society. This allowed more detailed understanding of their argument, its source material and the theoretical and political stances that underpinned it. Experience showed that the interviews with commentators required a more flexible structure than those with scientists, reflecting a greater diversity in role and employment history. Appendix A reproduces the schedule used for an interview with an individual employed by a pro-free market NGO.

4.4.2 Interview Administration

The administration of the interviews followed a standardised procedure. All were conducted in the interviewee's own office, whether in the UK or the USA. This reflected the hope that by travelling to the respondent's domain they would be encouraged to participate actively in the interview process, thus generating full answers to the questions posed. The strategy of conducting interviews in familiar surroundings for the interviewee is also intended to allow respondents to relax and, again, encourage freer and fuller discussion.

An initial round of interviews was planned to assist with the development of the interview design. This pilot phase consisted of four interviews with UK scientists working in fields related to climate change. These initial interviews proved an essential aid in testing and refining the interview schedule to ensure that had a coherent structure and that individual questions were both understood by respondents and generated an informative response (Fischer, 1997) (see Appendix B for pilot interview proceedings). As a result some changes were made to the detail of the interview schedule. For example, section 3, question 13 (Appendix B) was enhanced to provide clarification because the pilot interviewees misunderstood the question, generating conversation that did not really relate to the intended purpose of the query. The new question 13 can be seen in section 3 of Appendix C. It was also found to be necessary to add further questions to the schedule (see question 9, Appendix C). These were aimed at getting more specific and detailed answers from interviewees that explored their stance on the work of the IPCC. In some instances, therefore, the pilot study revealed the value of asking direct questions, despite previous concerns that this might prove too brusque. The pilot interviewees also provided an opportunity for the present author to practice and refine her skills as an interviewer.

An additional benefit from the pilot interviews was the opening offered to network with climate scientists, making contacts for full interviews, or establishing leads – or referrals – to facilitate approaches to potential interviewees. Thus some of the full interviews were first set up either by a pilot interviewee themselves emailing a suggested contact, or – more frequently – by offering a lead to be followed up by the author. The second round of full interviews involved contacting 59 individuals who were grouped according to the categories outlined in Figures 4.1 and 4.2. Interviewees

were first approached by email, using a carefully constructed letter that aimed to explain the focus of the study being undertaken. This also gave the contact the opportunity to explore the research further by visiting the specially designed project web page (www.geog.leeds.ac.uk/people/a.matthews/). Appendix D reproduces the letter sent to these individuals. A large number of people were contacted initially because it was anticipated that many would decline the request for a lengthy interview. However, the response was gratifying and yielded more than enough potential participants for a study on the present scale. In total 19 individuals were interviewed: 10 protagonist scientists, 4 sceptical scientists and 5 social commentators. Their distribution within the more specific categories outlined above can be seen on Figures 4.1, 4.2 and 4.3 (interviewees are listed for convenience in Appendix E). Some categories remain un- or under-represented; this reflects the character of the wider population and thus the difficulties of identifying potential interviewees who fulfilled all the criteria.

The full interviews raised new issues about the need for care in administering the interviews and the use made of the results. Lahsen (1998) identifies the threat of libel suits when studying particularly powerful persons, such as climate scientists who have a high media profile. She notes that 'Libel suits are an important weapon among participants in the climate debate whose status, power and influence depend on their public and scientific reputations' (Lahsen, 1998, p.64). This, in turn, reflects the observation made by the well-known climate scientist Stephen Schneider (1990, p.201) that 'the most precious intangible a scientist ever owns is his or her reputation'. Even without a threat of litigation all researchers should abide by an ethical code of conduct both when interviewing and when analysing and reproducing the words of interviewees (May, 1995; see also research ethics and confidentiality, ESRC, 2003-2004). Prior to the interviews permission was sought to take a tape recording of the proceedings and the assurance was given that the recording could be switched off if the interviewee wished to communicate information or comment off the record. Those actors already in the public eye were accustomed to speaking to a third party in this way and were, therefore, aware of the consequences. Individuals with less experience of public exposure may have been less aware of the potential consequences of speaking openly. Two measures were taken, therefore, to avoid possible embarrassment or complications. Following standard ethical practice, as recognised by the Economic and Social Research Council (2003-2004) in research on scientific issues, it was decided that all interviewees would remain anonymous. References made in the interviews to other named

individuals were also anonymised. Interviewees were given the further reassurance of an opportunity to view a transcribed copy of their own interview and to edit or clarify its contents. Thus, all involved in the study would be assured of the accuracy of the record of the interview and the risk of ill-feeling between interviewer and interviewee minimised.

4.5 Methods of Interview Analysis

4.5.1 The Mechanics of Analysis

Dey (1993, p.24) notes that qualitative data analysis 'is a process that involves describing the data, breaking it down into bits, looking at how these bits interconnect and generating a new account by reconceptualising them'. In the present case the analytical process had to reflect the need for closeness to the data; typically, indeed, qualitative data analysts are expected to 'immerse themselves in their data, get close to it and get the feel of it' (Stroh, 2000, p.262). The analytical process also involves making conceptual connections, searching for and explaining structures in the data. Patterns in the data, regularities, variations, exceptions, differences, commonalties and connections between interviews need to be drawn out. It was also important to be systematic about analysing the data if valid, coherent and intelligible accounts were to be produced from the initial substantial resource of material generated in the semi-structured interviews (Dey, 1993).

As analysis is a lengthy and complex process, the scale of which inevitably increases as the number of interviews mounts, it was necessary to find an efficient and productive way of handling a large amount of empirical data that would not compromise the previously stated need to engage closely with the material. This pointed to the adoption of Computer Assisted Qualitative Data Analysis Software (CAQDAS), rather than the use of traditional manual methods. Before the introduction of specialist computer packages in the late 1970s and early 1980s manual methods of analysis, often involving the use of coloured highlighters and index cards, were ubiquitous (Bagnall, 2003). Computer packages, however, have created easier and, usually, faster methods.

4.5.2 Why NUDist?

CAQDAS can be divided into two forms of packages, code and retrieve and code-based theory-building software packages. A number of CAQDAS exist including, for theory

building: NUDist, AQUAD, HyperRESEARCH and Atlas/ti; and for code and retrieve purposes: HyperQual, Kwalitan, QUALPRO and The Ethnograph (Fielding, 1994). The two groups of packages are not, however, quite so distinct as this categorisation might suggest. Even the most sophisticated packages require continued analytical input from the researcher (Bagnall, 2003; Crang, 1997). Moreover, the way in which specific packages are used may vary given the circumstances of individual projects. Rather than exploiting their full range of capabilities, theory-building packages may be used, as is the case here, for simpler tasks involving data coding and retrieval.

A general case can be advanced for the use of CAQDAS in relation to the present project. Computer-based systems are well-adapted to handle a body of complex, but similar, data sets. They speed the process of undertaking multiple searches through the information. This should increase the efficiency of the process of coding the text and assigning tags to particular segments that is a vital stage in structuring the interview material. CAQDAS also facilitates rapid retrieval of specific sections of the data (Coffey *et al*, 1996; Fielding and Lee, 1991). These capabilities are extremely important in highlighting the themes present in climate scientists' discussion of their own practice and the wider context in which they operate. Against this must be set warnings that unthinking use of computer software stifles creativity and alienates researchers from their data (Barry, 1998; Buston, 1997; Marshall, 2001; Richard, 1997). An awareness of these potential dangers makes them easier to resist. In practice, as in the present case, the initial process of transcribing, correcting and coding the interview transcripts frequently guarantees the necessary closeness to the data to allow sensitive analysis. There is thus little reason to reject the speed and efficiency of computer-based analysis in favour of a slower and more laborious process of manual coding and retrieval.

The decision to use CAQDAS led, in turn, to consideration of the particular package that would best meet the specific needs of the research and the circumstances of the researcher. Thinking was informed by five key considerations. Firstly, the package adopted had to be capable of drawing out specific information from the data to help provide answers to the research questions posed by the current thesis. Secondly, the software had to be capable of representing the breadth of material contained in the interviews, rather than offering only a selective view of the interviewees' perceptions and ideas. It was also important to feel confident that the package could help to identify the extent to which content and opinion was common to a number of different

interviews, as well as highlighting unusual or distinctive individual perspectives. Thirdly, it was important to reflect upon more practical issues regarding the ease of use of particular packages. This related to the fourth issue; the need for confidence that use of a specific package would truly prove a labour- and time-saving device. Finally, the limited budget available for the thesis raised issues about the cost of the chosen package.

This mixture of practical and academic concerns militated in favour of a pragmatic solution. This involved the use of the NUDist (non-numerical, unstructured data, indexing, sorting and theorising) package, which was, at the time, employed elsewhere in the School of Geography at the University of Leeds. Hence, if problems arose with the application of the package help would be at hand. The experience of others facilitated a speedy introduction to the use of NUDist for the present researcher. There were also cost savings, as it was necessary only to purchase a licence to use the package, rather than investing in new software.

NUDist has the capabilities required for data storage, coding, and retrieval, so assisting in the tasks of data control, data sorting into theme areas and hence efforts to reveal and explore relationships within the data (Gahan and Hannibal, 1998; Stanley and Temple, 1995; Stroh, 2000). Indeed, as a programme designed to assist in the development of grounded theory NUDist has potential powers which are not fully harnessed in the present case (Charmaz *et al*, 2003; Kelle, 1997; MacMillan and McLachlan, 1999). Previous studies have, however, successfully demonstrated the use of NUDist in the more 'limited' role proposed here, that is as a code and retrieve programme (for example, Mechanic and Meyer, 2000; Phyne, 1999; Speller, 2000; Yuksel, 2003).

4.5.3 NUDist in Practice: The World of Coding, Searching and Retrieval

Qualitative studies use coding to categorise data rather than to quantify it. Hence coding is described by Calloway and Knapp (1995, p.3) 'as a process of simultaneously reducing the data by dividing it into units of analysis and coding each unit'. Kelle (1997, p.12) echoes this, claiming that coding is the first process in analysis through which 'the analyst tries to make sense of the data'. Ultimately, coding is designed to bring a degree of order and organisation to the analytical process and to the text under interrogation. NUDist uses 'an elaborate – and largely prescribed – coding strategy' (Stroh, 2000, p.246) based on the development of a system of thematically-defined

'nodes' which form the primary structure for data organisation. Nodes may be identified through the initial interrogation of the data in relation to key research questions, or derive, as is chiefly the case here, from prior theoretical insights (Tesch, 1990). Critically, also, NUDist allows the researcher to allocate any specific text unit to many different nodes, thus building up an overview of the potentially complex interrelationships between different themes.

The system of nodes employed in the present study is outlined on Figure 4.4. As the figure shows these nodes formed two distinct groups. The first – dubbed 'base data' – are designed to assign text in relation to the personal characteristics of the interviewee. The distinctions drawn reflect the considerations outlined earlier in discussion of the choice of interviewees (Section 4.3). Given the efforts that have been made to include interviewees from both the UK and USA, both climate sceptics and protagonists, both scientists themselves and social commentators, and those differing in career stage, institutional affiliation and media experience, it is important that in the subsequent analysis specific information and opinion can be linked back to individuals with particular personal characteristics. Figure 4.4 also shows the way in which the organisation of data within particular nodes can be facilitated by the development of a series of sub-nodes, thus forming a hierarchical 'tree construction'. In several instances the choice of sub-nodes reflects the basic polarities inherent in the initial decision-making about the identification of interviewees. Nationality, for example, is adequately represented as a two-fold division into US and UK interviewees. Similarly, the tree structure repeats the simple distinction made earlier between protagonists and sceptics with regard to position on climate change. Other nodes required decisions to be made about how the range of interviewees could best be represented, without developing an overly complex system of sub-categories. Thus interviewees were, for example, allocated to a series of age groupings and their working environment defined by institutional type.

Fig. 4.4: Nudist Tree Construction

1. Base data

1. Gender

1. male
2. Female

2. Nationality

1.US
2.UK

3.Age

1.20s
2.30s
3.40s
4.50s

4. Career

1. Scientist
2. Social scientist

5. Leaning

1. Contrarian
2. Protagonist

6.Career stage

1. Dr
2. Prof
3. BSc / MSc

7. Media experience

1. A lot
2. Some
3. Little/none

8. Work context

1. university
2. Government
3. Business
4. NGO
5. Other

2. Themes

1. IPCC

1. Involved with
2. Peer review
3. Positive comments
4. Negative comments

2. Government and legislation

1. UK government
2. US government
3. Climate legislation and Kyoto

Fig. 4.4: Nudist Tree Construction (continued)

3. Business

1. Fossil fuel companies
2. Utility companies
3. Insurance industry
4. Restratigising
5. Business and funding

4. Funding

1. Personal funding
2. State of funding
3. Personal income

5. Role of science and scientists

1. Idealisation
2. Social context involved
3. Policy involvement
4. Perception of scientists

6. Environmental topics

1. Global warming
2. Ozone depletion
3. Other

7. Peer review

1. Negative comments
2. Positive comments
3. Proposals
4. Publishing

8. Individuals

1. Sceptics
2. Protagonists

9. Agencies

1. Hedley Centre/Met Office
2. NGOs
    1. Pro-environmental NGOs
    2. Anti-environmental NGOs

10. Media

The nodes representing interviewees' characteristics cross-cut with a second series designed to reflect the main themes of the research. The initial identification of these nodes primarily reflects ideas and insights derived from the theoretical perspectives discussed in Chapter Three, together with issues raised in previous explorations of the context in which climate science is produced (for example, Beder, 2002; Boehmer-Christiansen, 1997; Gelbspan, 1998). The choice of nodes was, however, confirmed through a careful first reading of the complete body of interview transcripts. This engagement with the interview material itself also played an important part in the identification of sub-nodes. Indeed, in some instances, the process led to the inclusion of sub-nodes that had not been previously anticipated. Earlier thinking had not, for example, explicitly raised the issue of the potential for personal financial gain – as opposed to additional research funding – for individual scientists as a result of adopting a particular stance on climate change. This was, however, raised by several interviewees and the decision was thus taken that it warranted inclusion as a separately specified dimension of the thesis' key concern with financial aspects of the relationship between science and society. The analysis thus benefited from the flexibility afforded by NUDist to extend the system of nodes and sub-nodes.

Discussion in Chapter Three began by identifying different theoretical perspectives on the relationship between science and society. It was noted that although the idealisation of science as a separate realm is unsustainable in practice it remains potentially important as an apparent justification for the privileged status often claimed for science. Moreover, the idea that science represents a world apart is still inherent in much scientific training. It is important, therefore, to understand how interviewees regard the position of science in general, and their own status in particular, especially in relation to subsequent discussion of the ways in which science may be compromised by links with key commercial and political actors. The role of science and scientists was thus identified as a node (Node 5 on Fig. 4.4). It was further subdivided to focus attention on the specific issue of the idealisation of science as separate and disinterested, as against evidence of the ways in which scientific practice was influenced by external actors and/or a desire on the part of scientists to participate in the process of informing and making commercial or political policy. To complement this attention to wide-ranging discussion of scientific practice a further more specific node (Node 8) was established to bring together comments regarding the different scientific perspectives on climate change and the individual researchers advancing them.

From this starting point discussion, both in the present thesis and in previous analysis, has focused particularly upon finance as a fundamental link connecting science to other societal forces. Chapter Three reflected in some detail on the theoretical logic for external sponsorship of particular types of science. In rejecting a determinist link between a unitary sub-structure and scientific activity in favour of a more complex neo-Marxist understanding, discussion in Chapter Three raised a series of questions for empirical investigation. These could not all be encompassed under a single node. One series of questions revolve specifically around funding itself, leading to the identification of a node with this title (Node 4). This was employed to bring together ideas and opinions about the availability of funding from particular sources, scientists' perceptions of the pressures – both personal and institutional – to obtain funding, and, as noted above, any links between funding, research and personal financial gain. Two further, related nodes focus on the two main agencies identified as external influences upon, and sponsors of, science: Government (Node 2) and Business (Node 3). These nodes allowed attention to funding to be cross-referenced with wider discussion of the characteristics of government and business, their attitudes towards climate change, and their aims and agenda in advancing (or withholding) funding to specific sectors of climate science research. The recognition – which is both theoretical and empirical – that neither business nor government necessarily represents a single unitary interest is reflected in the creation of a series of sub-nodes. In the case of government the primary distinction to be drawn reflects the different stance of administrations in the UK and the USA. A further sub-node was also introduced that reflects the growing role of international diplomacy in the discussion of political responses to climate change. With regard to business, several of the sub-nodes reflect evidence of difference between particular sectors, such as energy providers and the insurance industry, in their attitudes towards climate science. Additional sub-nodes derive from previous attempts to categorise the behaviour of business in general with respect to environmental challenges. This recognises that sponsorship of science is only one option. Business may attempt to change its own behaviour – or at least give the illusion of change – in ways that affect their attitudes to the underlying environmental science. The potential role of other agencies, less as a source of substantial research funding, but rather as an influence upon the ways in which climate change is understood and discussed is recognised in Node 9.

Previous characterisation of the position of scientists themselves has rejected the assumption that recognition of their financial dependency on external actors necessarily implies the total loss of independence or status. This, too, requires further investigation, focusing on the potential foundations of scientific expertise and influence. The most significant institutional embodiment of scientific expertise with respect to climate change is the IPCC, which is arguably so important as to merit a node in its own right (Node 1). This decision also reflected the controversy which the IPCC's work has sometimes attracted given its strong links with political policy-making at both a national and an international level. The IPCC nodes is thus subdivided in ways that define interviewees' levels of involvement with the panel's operations, but also the divisions of opinion about the rigor of its science and the extent to which its work acknowledges the full range of scientific opinion.

Beyond the work of the IPCC, however, scientists themselves make a potentially vital series of decisions about the allocation of research funding and the dissemination of research findings. These have an impact on both external perceptions of scientific expertise and the profile of specific scientific perspectives on climate change. These considerations are brought together in Node 7 'Peer Review'. This encompasses interviewees' thoughts about the influence of their peers as it relates, firstly, to consultation and review concerning research priorities and the allocation of funding, and, secondly, to publication in academic journals. The node is structured so that suggestions that both these processes operate in ways that discriminate against particular strands of opinion regarding climate change can be cross-referenced with wider perceptions of the strengths and weaknesses of the peer review system. This node is also intended to bring together observations about the location of authority within the academic realm and the extent to which it is held chiefly by a small elite of senior scientists.

It is also important to recognise the potential importance of the media (Node 10) as an alternative means of information dissemination; one that might be used particularly by interests and individuals aiming to influence public and political perceptions of climate change, or by those disenchanted with the process of peer review (see section 4.3.1). The dissemination of scientific results and opinion through the general media can reinforce the image of the scientist as expert. Yet there is an accompanying risk that scientific work is misrepresented in the media, contributing to a loss of public faith in

scientists' powers to explain relationships between human and environmental systems. The node, therefore, pulls together material about interviewees' attitudes towards the media, their differing degrees of involvement, and the motives that prompt some to develop a high media profile.

4.5.4 Coding and Retrieving Data

The process of assigning the text to relevant nodes has three main stages (Buston, 1997). The first is the introduction of the complete data transcript into NUDist. This is followed by a stage of interrogation through which text units – typically a sentence or a paragraph – were assigned to appropriate nodes and sub-nodes. The final stage is that of the retrieval of data in an organised form for the research task in hand.

As NUDist is a sophisticated software package many different search options are available. For this study, however, greatest use was made of the (string) text search option. This not only allows the efficient retrieval of text relating to specific nodes and sub-nodes, but also the rapid execution of a series of cross-referencing exercises. Hence, for example, it was easy to see whether climate scientists' differing positions as protagonists or sceptics regarding global warming influenced their perceptions of their peers, funding sources and specific means of information dissemination. Other base data nodes were also independently searched against key thematic nodes such as funding. This method of retrieval resulted in the collation of sections of different transcripts linked by particular themes as an initial structure for the presentation of the empirical material in Chapters Five and Six. NUDist rapidly retrieved the relevant data, formatted the text and provided reference information to identify the interviews from which the linked text units had been drawn. NUDist also allows the researcher to save the combinations of text units brought together by a specific search, providing a concrete resource for textual analysis.

4.5.5 Reflecting on the Tree Structure

The tree structured discussed above is not, of course, the only one that could have been developed to facilitate the current research. Greater refinement might have been introduced into the textual analysis by the inclusion of additional nodes, or the greater use of sub-nodes. This potential must, however, be set against the risk of creating an

analytical framework that is so complex as to be self-defeating. As Richards and Richards (1997) note there is little virtue in generating an information overload that merely obscures understanding of key links and relationships. A conscious decision was made, therefore, to limit the number of themes that would be identified as nodes in their own right.

It was also the case that some key themes were difficult to contain within a single node. 'Influence', for example, is an important notion that runs through much of the present discussion of climate science. Yet precisely because of this, influence proved difficult to categorise and accommodate within a specific node of a tree structure. Instead the theme of influence seems best to be captured through consideration of the ways in which its various dimensions are represented in other nodes, particularly business, government, funding, the role of science and scientists.

Although the structure represented in Figure 4.4 proved a robust framework for analysis, hindsight suggests ways in which it could have been improved. Some of the distinctions drawn in the identification of sub-nodes, in particular, seem overly subjective. This is true, for example, of the simple divisions adopted in categorising interviewees' media experiences which were vague and based on personal judgements, rather than any specific measure of activity. The two-fold division of interviewees into climate sceptics and climate protagonists – noted earlier as an over-simplification – also caused some problems. While some interviewees readily identified themselves with one of these two positions, others did not want to be seen to be labelled in this way. Their allocation by the researcher on the basis of the interviewees' published work, as well as the attitudes revealed during the interview, thus introduces a note of tension.

4.6 Elaborating on the Practice of Data Collection and Organisation

This chapter has set out the thinking – both theoretical and practical – which informs the methods adopted in the empirical core of the thesis. It appears that answers to many of the key questions previously posed about the practice of climate science are best addressed through direct engagement with the ideas, opinions and understanding of actors directly involved in scientific research. It follows that semi-structured interviews with scientists themselves, and with a smaller number of informed social commentators, will be central to the research. Although this form of qualitative research necessarily raises questions about the number and representativeness of the individuals identified as

interviewees and about the credibility of the accounts put forward, no other method seems likely to offer a better or closer insight into the world of climate research and the perceptions of its practitioners.

It is, moreover, possible to address some of the problems raised by interview-based research by care in its execution. This is reflected here in the efforts made to identify the range of different types of interviewee who should be included in any sample; in the use of a semi-structured interview schedule to give the best combination of flexibility and consistency in the conduct and content of individual interviews; in the pilot testing of the interview schedule; in the adoption of good practice regarding anonymity and the ethical treatment of interviewees; and in the systematic analysis of the interview material using a consistent framework of themes deriving from the theoretical foundations of the project. Furthermore, the interviews are embedded within a wider process of data collection and analysis, involving the extraction of information from sources including secondary studies, media material, web sites and official publications. These alternative sources not only add to the richness of the information available, they also strengthen the interrogation of the interview results.

As noted at the outset of this chapter, the present research draws upon a range of secondary material, elements of which were employed both as sources of information in their own right and in establishing a context for reflection upon the interview data. Recent academic publications by interviewees and their peers in key journals, including *Nature* and *Science*, provided insight into the content of the unfolding academic debate, but also served as a means to test some of the assertions made by interviewees about the extent to which the full range of scientific opinion is represented in the published academic literature. Exploration of alternative means of information dissemination, particularly the burgeoning opportunities for electronic publication of research and opinion pieces, allowed further judgements to be made about the extent to which more contentious views are able to find an outlet. It would have been interesting, but very difficult in practice, to have made some assessment of the relative impact of different means of publishing scientific research and opinion, in terms of the size and composition of their audiences and the reliability imputed to different media by their readers.

Secondary sources were also employed as a source of official information about the activities of major state funding agencies in the UK and USA. Material published by research councils and related bodies was vital in defining the public face of such organisations. In particular, attention was paid to published statements of the scientific themes or subject areas identified by agencies as research priorities, and to the record of projects recently funded by specific agencies. Such information provided an invaluable counterpoint to the accounts given by interviewees of their experiences of seeking research funding from these same agencies and the assertions made that funding was disproportionately directed towards particular types of research, or those with more 'conformist' views on climate change.

A similar combination of conventional publications and web-based material was also employed as a means of exploring the perspectives on climate change and climate research advanced by selected NGOs. Specific organisations were identified which could be taken to represent different strata of opinion, ranging from NGOs with a primary interest in environmental protection, such as Friends of the Earth and Greenpeace, to those with a mission to combat restrictions on the capitalist free market, such as the Institute of Economic Affairs and the George C Marshall Institute. The activities of such organisations are important in their own right, in relation to the dissemination of particular scientific opinions and, to a lesser extent, their sponsorship of scientific research. Information about these NGOs also served a wider purpose in relation to the overall research design by again providing an alternative record of debate concerning climate change, which could be set against the accounts offered by interviewees.

The existence of material produced by organisations such as Greenpeace or the Marshall Institute which publicly proclaim a particular agenda regarding the relationship between economic development and environmental protection highlights the need to treat with caution the opinions and assertions of all parties in the climate change debate. Exploration of web-sites and other publications allowed some assessment to be made of the extent to which scientific research – and the expert status of individual researchers – is used in practice in an attempt to validate particular points of view.

Use made of interview data in the subsequent chapters was also informed by secondary information compiled about the academic history of individual interviewees. This

included particular attention to their record of publication on climate change and any recorded public statements about issues relevant to climate change per se, climate research, the regulatory role of government and the environmental responsibilities of business. In the case of individuals with a high public profile attention was also paid to expressions of opinion about them found in other sources, including the print and broadcast media. In some instances the impression gained in this way of the stance of particular individuals on climate change research appeared at odds with the evidence of the interview itself. This reinforced the need for careful examination of the interview transcripts against a range of other sources.

The use of NUDist as a device for organising information derived from the full range of interviews also facilitated comparison of the accounts of particular issues offered by individual interviewees. Consistency in the accounts offered by individuals increases confidence in their underlying accuracy. However, there were also instances where comparison identified revealing discrepancies in opinion or experience. For example, most climate sceptics indicated some measure of frustration at the lack of official funding for research which questioned majority scientific opinion about the causes of climate change. Exceptionally, however, one of the most prominent sceptics professed to have experienced no such problems in obtaining funding. This suggests the need for further reflection on the extent to which individual reputation and media profile plays a part in the distribution of research funding.

Overall, the process of triangulation was successful in highlighting some contradictions in the accounts of individual interviewees that would not otherwise have been apparent. It also allowed a distinction to be drawn between those views that were peculiar to individuals and those that were more widely shared by the interviewees as a whole, or within specific sub-sets amongst them. Where such diversity became apparent it also prompted further reflection regarding the extent to which it could be explained by known differences in the interviewees' scientific views, national and institutional context, career stage and external interests. In practice, however, this process of comparison could only be partial. For example, for reasons discussed earlier it was not possible to identify and contact a cross-section of UK scientists whose declared stance on climate change fully matched the range of opinions evident in the USA. In particular, the limited number of self-declared climate sceptics in the UK made it difficult to undertake direct trans-Atlantic comparison of some strands of opinion.

4.7 Conclusion

The process of interviewing individual scientists – especially those with a high academic and public profile – was daunting, especially in its early stages. A minority expressed their opinions very forcefully and were confrontational in rejecting any alternative viewpoint raised during the course of the interview. In such circumstances it was particularly difficult to explore more sensitive issues about access to funding and the judgements made through systems of peer review. Given more time and greater resources it would have been beneficial to have recruited a larger number of scientists as interviewees. It would also have been interesting to have been able to undertake shorter follow-up meetings with some of my initial interviewees, asking them to reflect on issues raised by others during the course of the programme of interviews.

For the most part, however, it is gratifying to record the interest shown in this research by the scientists contacted and their willingness to grant me time within their busy academic schedules. The use of semi-structured interviews was generally successful in defining a common agenda for all discussions with individual scientists and commentators. An initial stage of pilot testing helped to ensure that the questions posed were logically organised and readily comprehensible for interviewees. At the other end of the process the use of NUDist as a means of data organisation allowed me to bring together different perspective on key research themes, identifying the degree to which common ground existed between interviewees. The same process also served to highlight discrepancies within specific interviews, and between the accounts offered by particular individuals and their peers, or between interviewees and other secondary sources. This ability to translate the generality of interview material into specific issues for exploration and explanation is vital to the success of the account that follows.

The structure of the following empirical analysis takes us back to the themes of research funding and dissemination identified at the start of the present chapter. Attention in Chapter Five focuses on scientific funding and the relationships created with external sponsors. This is followed in Chapter Six by discussion of the dissemination of the results of scientific research, potential differentials in the experience of climate protagonists and sceptics, and potential links between claims of scientific legitimacy and expertise.

CHAPTER FIVE

Funding Climate Scientists

5.1 Introduction

The involvement of social, economic and political forces in the funding of climate science in economically liberal societies requires analysis because of its potential influence upon the practice of scientists. When an explicit relationship exists between the scientist and funder, scientific integrity can come into question. By interviewing climate scientists, it is possible to gain insight into how those involved in the climate change arena see their relationships with the external funding context.

As noted in Chapter Three, scientific research as a whole is reliant on support from the economic substructure. As a result, government and academic scientists apply for, and obtain, money from institutions such as research councils, government departments, businesses and NGOs. These agencies fund science for its societal, academic and commercial value. Chapter Three, section 3.2.2, highlighted a [two-way] symbiotic relationship between scientists who carry out the research and the institutions that provide the funding. The former seek financial stability for their research, prestige and potential career advancement. They also gain a sense of academic achievement from increasing knowledge. The latter exploit the opportunity to purchase 'useful knowledge'. Building on this theoretical statement of the relationship, this chapter will analyse the links between scientists on the one hand, and their funders on the other. Initially, this chapter will provide a contextual background for climate funding in the UK and US. This will be bounded within an institutional framework, focusing on governmental and academic institutions as the two principal contexts within which climate scientists undertake research. This will be set against the perceptions of individual climate scientists to explore the ways in which both contrarians and protagonists discuss the availability of funding.

The chapter begins by outlining the institutional framework of the UK and US funding system, highlighting the procedures through which grants are obtained. It goes on to

explore the funding sources available for climate research in the UK and US and the relative size of the available budgets. Such empirical material concerning the funding system is an important starting point for greater understanding of the modern practice of climate science. It also provides firm evidence against which to compare the more impressionistic interview material, as well as providing an evaluation of the commitment by the UK and US to climate research. Although it is not, of course, a measure of their determination to reduce greenhouse gases.

Section 5.4 considers the extent to which climate scientists are independent from the economic substructure of society, and therefore how influential they are within the climate debate. It therefore provides an insight into the pressures upon scientists to gain funding to undertake research. This section then investigates the effects that dependence on funding has upon the manoeuvres of climate scientists, reflecting on the extent to which objectivity is compromised to carry out research. This section, therefore, explores the perceptions of the scientific community about the objectivity and integrity of climate scientists' work.

This discussion will be set against previous work by Paterson (1996a) and Hart and Victor (1993), who suggest that political decision-making on climate change is influenced more by a minority of high-profile, well-connected, expert climate scientists than by the generality of bench scientists (see Chapter Two, section 2.5.1). It will also reflect upon the arguments of Boehmer-Christiansen (1994a, 1994b, 1995, 1997), who claims that IPCC protagonist scientists have altered their practice for specific gains, and in contrast, Beder (1997, 1999), Rowell (1996) and Gelbspan (1998) who argue that sceptics' research is biased in being influenced by their funders – corporations that have vested interests in debunking anthropogenic climate change.

5.2 Contextualising Research Funding

Researchers are all dependent, albeit to differing extents, on financial support to fund their studies. Funding is required so that new knowledge and understandings can be generated within a field, helping the subject to stay at the forefront of research. Funding is more important in some disciplines than in others, with scientific projects habitually demanding more resources than research in the social sciences, arts and humanities. The

tradition of individual scholarship in arts and humanities accounts for some of the differences, which also reflect the dependence of science upon (often expensive) equipment, laboratory use and fieldwork (Higher Education National Report, 2001). For example, high specification computers are expensive yet essential tools for climate modelling (Shackley *et al*, 1998). Certain types of scientific research, such as pharmaceutical and biotechnological science, consistently attract significant funding in western societies primarily because of their potential to improve corporate profitability by generating commercially relevant knowledge (see Chapter Three).

Funding for research in developed societies can be obtained from various authorities, including business, government, charities, research councils and NGOs. The grants which are awarded by these bodies determine 'who can and cannot carry forward a research programme' (Spier, 2002, p.103). However, their procedures and rationales for funding research are different. Commercially-funded research is likely to be more focused on particular short-term commercial goals, and innovative research, such as creating new products and solving specific technological and managerial problems (Ashford, 1983). By contrast, state funding often has broader objectives relating to policy formation and review, as well as longer-term societal, economic and environmental concerns. Thus, it appears that research which regularly obtains grants reflects and reinforces Western ideals and values. Although grants may derive from similar authorities within countries such as the UK and US, the institutions are not necessarily identical in their practice (see section 5.3.3).

Since the 1980s, UK and US government funding has become more explicitly focused upon applied knowledge, with valuable knowledge being considered as that which is commercially and politically useful (Daly and Wakeford, 2002; Tudge, 2002). Industrial funding of research has also increased, although it is by no means a new phenomena (Ashford, 1983). As a result, only certain types of research are 'bought' (funded), suggesting certain commercial and political expectations about its use and outcome. Boehmer-Christiansen notes that in the contemporary context 'research is given objectives and targets' making it far more accountable to the sponsoring body (Boehmer-Christiansen, forthcoming, p.10). In the UK the declared aim of the funding council with particular interests in environmental change and climate science – the Natural Environment Research Council (NERC) – is 'to put NERC science to work'

(NERC, 2001). It is evident that the bulk of NERC's total funding is devoted to research which is claimed to have direct societal and political value. NERC distributes its funds according to strategic objectives which stress the importance of applicable science. Thus, 'strategic themes' shape research agendas and direct funding to priority areas. NERC funding is divided into four categories according to strategic themes: non-thematic funding, thematic funding, core strategic funding and infrastructure funding. With the exception of non-thematic funding (basic science), research within these categories is designed to have the potential for both theoretical and applied work, the argument being that research is all the stronger for this approach. NERC's 1999-2000 report highlights a large difference in funding between non-thematic and thematic strategic research, with 77% of their budget designated to thematic or strategic priorities (NERC, 2001).

Other British research councils also emphasise the importance of social relevance. The Biotechnology and Biological Sciences Research Council (BBSRC) now claim that 'research committees will focus more tightly on the strategic relevance of grant applications' (see BBSRC, 2000, p.4). A similar stress on strategic research is also evident in the US where 80% of all research funding is directly related to such knowledge. By comparison, the National Science Foundation (NSF), set up explicitly to fund basic science, receives only 20% of all federal support for academic institutions (NSF, 2001). It is also the case that within the EU proposals are assessed according to their political value: 'policy relevance plays a major role in the evaluation process' (IGFA, 2000, p.15). This suggests that societal value is accorded to the advancement of knowledge, both pure and applied. Moreover, research which could potentially have direct societal and commercial value is perceived by economically liberal societies to be more valuable, as it could contribute to the advancement of economic growth.

It follows that particular research disciplines, and types of research within disciplines, obtain more funding because of their direct social or policy relevance. Whether research is basic or applied, therefore, significantly affects the amount of funding obtained, as well as the funding source (Higher Education National Report, 2001). In practice, however, the division between basic and applied science in modern western societies is not necessarily so easily defined. Applied knowledge originates from basic scientific principles. For instance, climate system research requires fairly basic work on one level,

which is later connected to applied science. Applied knowledge may also lead to basic science if the former produces previously unknown knowledge. It is, therefore, the case that there is often a strong connection between basic and applied science. As a result, it is perhaps more accurate to describe basic science as quasi-basic.

5.3 The System: Money, Dependence and Pressure

5.3.1 Outlining the System: Procedures to Obtain Funds in the UK and US

The procedures to obtain state funding for generic scientific research in the UK and US involve three principal bodies: the government, research councils, and scientists. Closed tendering does not occur in academic research. Although the exact procedures differ between countries, the overall process is quite similar and can be divided into four principal stages:

- Stage one: the state sees value in promoting research. Research Councils' overall objectives are to promote research and to take responsibility for distribution of state funding. As a result, there is a need for a regular dialogue between governments and research councils to define general priorities for research and the scale of available funding, which will determine the total annual grant to a research council. This is the main context for government involvement (refer to stage one, Fig. 5.1).

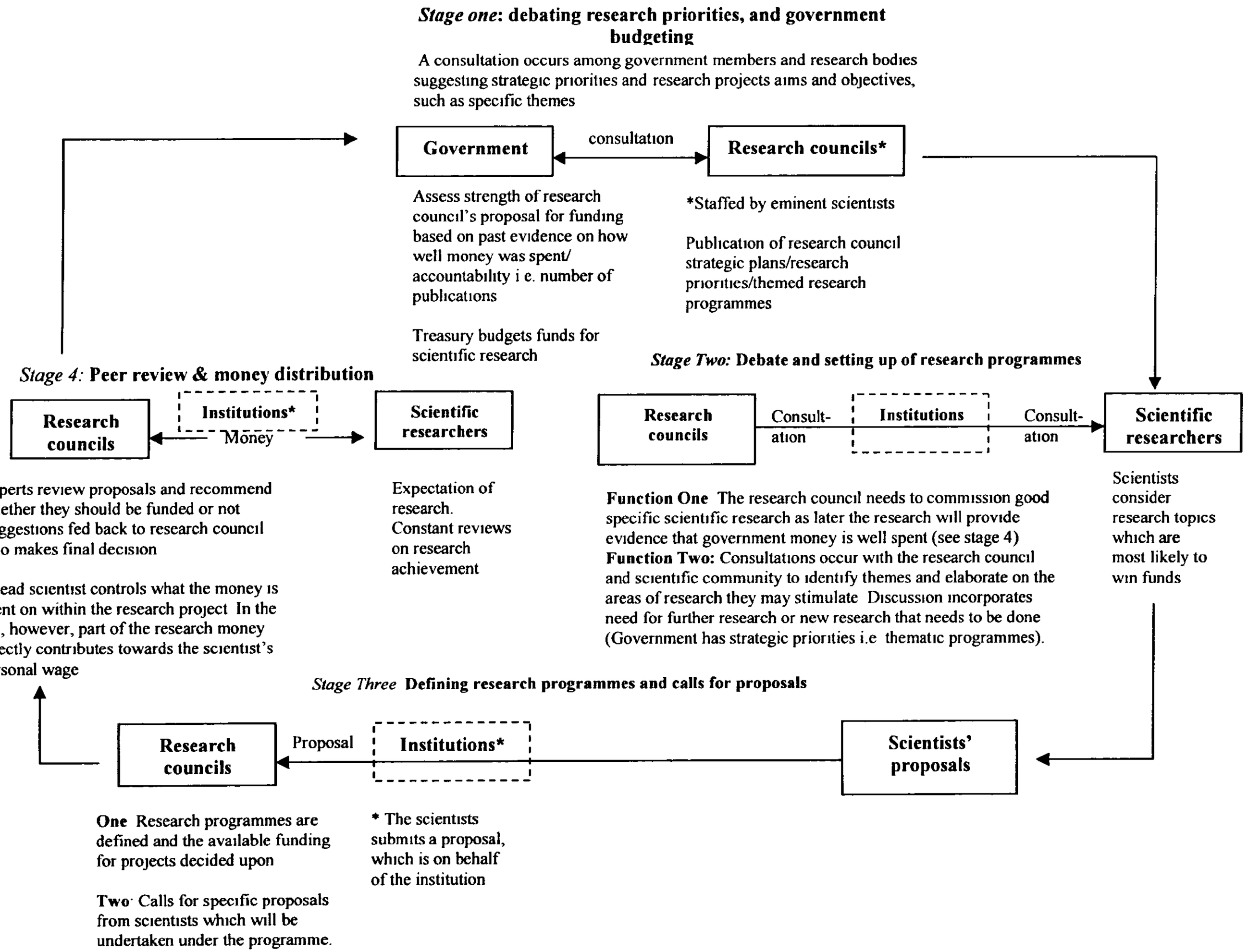
- Stage two: research councils themselves are engaged in a process of justifying their continued existence. This means making sure that the value of previous research council funded work is as widely appreciated as possible. It also involves showing that they have some sense of strategic direction for the future, which is exemplified by the creation of thematic or strategic priorities. These are areas identified in general terms as foci for funding over a five to ten year period. The definition of these thematic priorities will reflect consultations with the government and analysis of policy priorities. At the same time, consultations will occur with the scientific community to identify themes and to elaborate on the areas of research they might stimulate (see stage two, Fig. 5.1).

- Stage three: this leads to the definition of research programmes as a way of guaranteeing the research priorities. Again, there is academic consultation to define the form and content of the programme and the amount of funding available. Calls are issued for specific research proposals that will be undertaken under the auspices of the programme (see stage three, Fig.5.1).

  However, research is also undertaken outside such specific programmes. The latter only account for a small proportion of the funded research. In many instances individual researchers are asked to respond to the research priorities directly; to show how their own particular projects relate to overall research council goals.

- Stage four: By the stage of specific proposals the refereeing process starts to become more refined. Individual proposals are reviewed by designated experts in the relevant field. Their recommendations about whether a proposal should be funded or not are fed back to the research council's own committee which make the final decision (see stage four, Fig.5.1). Usually there are far more good projects than there is money available to fund, meaning that competition for scarce resources is intense (Chubin, 2002).

Fig. 5.1: A Crude Four Stage Process of Funding Mechanisms in the UK and US



Thus, the state funding of scientific research is a process that relies heavily on the knowledge of the broader academic community, those scientists who review and shape the research themes and research programmes, and who review the individual research proposals that follow. This implies technocratic control of the funding system by scientists. However, other influences, such as governments, are also present in this decision making process. The type of research to be funded is not solely informed by scientists as suggested, but also by business and other actors. Hence the emphasis placed on identifying the non-academic 'users' of specific research at the proposal stage, which is intended to ensure that research meets the needs of a wider audience (refer to Fig.3.1, Chapter Three).

Many of these other actors, particularly business, themselves directly fund research, and invite researchers to work for them. In some instances this involves a process of closed tendering, where there is no open competition. This could be perceived as an alternative to state grants and, perhaps, a more straightforward route for established researchers to obtain funding. However, money derived from commercial sources potentially has

> indistinguishable from those of the corporations funding them. While claiming scientific detachment they are, in reality, no more than obedient employees of industry, which is governed not by an unbiased assessment of human need but by the hope of making money (Monbiot, 1995, p.1).

To understand how the funding systems operate in the UK and US requires an examination of the grant awarding bodies, who they are, how they function and how much they contribute to climate related research. Such information may go some way to explain the interviewees' perceptions (see below) regarding the practice of fellow climate scientists. For example, if climate scientists have become entrepreneurial, then it should follow that more funds would be available for climate research, as they have been successful in influencing funding resources.

5.3.2 Funding Sources for Climate Research in the UK and US

This section will identify the state agencies that fund climate studies in the UK and US. Comparisons will be drawn between the different amounts spent by the two countries. Reference will also be made to the funding allocated by the European Union (EU),

which potentially complements the funds budgeted for climate work by the UK government.

Among the available funding sources, UK and US climate scientists also receive grants from the WMO, through the UNEP. The IPCC, however, does not directly fund climate research. Research shows that industry support climate research in both the UK and US (Leggett, 1999, Beder 1997, 1999, Rowell, 1996). Contributions to the research funding of individual climate sceptics are recorded by Beder (1997 and 1999) – amongst others. However, summary figures outlining the total value of corporate sponsorship in this field have proved difficult to find.

UK Climate Funding

Climate scientists can obtain money from the various British government funded research councils, such as NERC, BBSRC, the Medical Research Council (MRC) and the Engineering and Physical Sciences Research Council (EPSRC). It is also possible to gain funds from the Department for Environment, Food and Rural Affairs (DEFRA). DEFRA also funds the UK Meteorological Office, in association with the Ministry of Defence (MOD).

The UK government committed £200 million ($330m) over a three year period from 1997-1998 to 1999-2000 to climate change related activities through bilateral projects (DEFRA, 2001, p.68) DEFRA (formerly the Department for Environment, Transport and the Regions - DETR) funds the majority of climate change research, specifically including climate research and observation in which it invests about £12 million per year (DEFRA, 2001, p.74). Amongst the research councils it is NERC which spends the largest percentage on global change research. In the financial year 1999-2000 NERC spent 28% (£64m; $98m) of its total budget on 'global change' science in support of significant programmes of research linked to climate change (NERC, 2001; DEFRA, 2001). In contrast, the BBSRC spent only 19% of its funds on climate change research, a total of £1.5m ($2.5m) (IGFA, 2000).

However, government data on NERC funding for climate change science is contradictory. Although it is evident that NERC commits the majority of its funds to climate change research, the exact amount spent is recorded differently in various

sources. Figures from the IGFA, noted in Table 5.1, suggest that in 1999 NERC spent £51.1m on global climate research, whereas NERC and DEFRA quote a figure of £64 million during the same time period. While these figures may only be estimates, it is probable that the context for the calculations was slightly different.

Table 5.1: Total Funding for UK Global Climate Change Research (GCR) in Fiscal Year 1999

Agency	1999 Funding for GCR	
	£ million	US $ million
NERC	51.1	84.3
DOE	23.0	38.0
BBSRC	1.5	2.5
MAFF	1.7	2.8
Total (rounded)	**77.3**	**127.6**
NERC as % of this total	**66%**	

(Source: IGFA, 2000).

New government initiatives exemplify the UK's commitment to dealing with climate change. For instance, the EPSRC has recently launched a £2m programme on the impacts of climate change (DEFRA, 2001, p.75). Furthermore, three research councils, NERC, ESRC, EPSRC, have formed the Tyndall Centre to undertake interdisciplinary research on climate change (DEFRA, 2001, p.74). This growing investment in climate research throughout the UK highlights the increasing importance accorded to the issue by the UK's political and scientific elite. However, the amount spent on climate research is minimal, when compared, for example, with spending on defence of $31.8bn (MOD UK, 1999).

Although Table 5.1 provides a measure of the amount spent on global change research, the actual figure specifically devoted to anthropogenic climate change research is far smaller. However, an exact funding total for this latter field is impossible to find. This is because particular research councils will fund research that is directed more towards the implications of climate change, problem solving and preventative action. The EPSRC research is focused on more applied research, designed to be of direct societal and political relevance. For instance, it supports research related to adaptation to climate change and emission reduction, including sustainable energy. By contrast, the BBSRC

concentrates more on basic science, focusing on the impact of climate change on the function and behaviour of plants, animals and microbes, and soil processes (DEFRA, 2001, p.76).

US Climate Funding

In comparison to the UK, the amount spent on climate research in the US is much more substantial. The US spends approximately $1.6bn annually on climate change research (IGFA, 2000). As a result: 'the United States is responsible for half of the world's annual climate change research expenditure, three times more than the next largest contributor ... spending more than 15 nations of the European Union and Japan combined' (USGCRP, 2002). Indeed, over the past decade, the US has invested nearly $18 billion in climate change research. However, compared to America's defence budget of $259.9bn, the amount spent on climate change research is small (MOD UK, 1999). The trend of increased spending on generic climate science is set to continue. The President's Budget in fiscal year 2003 provides $4.5 billion for global climate change-related activities, a $700 million increase on the current annual funding commitment (White House, 2002). In addition, Table 5.2 highlights an increase in the US budget specifically for climate research of 8% ($59.7m) between 1999 and 2001. A further rise of 2% ($13.7m) is projected between the fiscal years of 2001 and 2002. However, the latter increase is in fact lower than the US annual rate of inflation, which was 2.80% in 2001 (World Information, 2002). Thus, this increase is not so impressive when put into context. On April 6 2001, the Senate passed a bill to 'restore funding for programs related to global climate change to the funding level of $4.5 billion [per year] over 10 years, primarily for existing programs addressing global climate change concerns' (Justus and Fletcher, 2001). Yet 'addressing global climate concerns' does not necessarily mean that all the money is spent on atmospheric climate change research. Indeed, the Issue Brief goes on to note that from this budget around one fifth of the money will be spent on tax credits for renewable energies. Therefore, such large amounts designated for climate research have a broader purpose which includes a degree of climate system work, but also research that is more directed towards the implications of climate change. For example, the Department of Energy is considered among the global climate change research funders in Table 5.2, although its priorities are applied and directed towards problem solving and preventative action related to climate change. Indeed, the 2002 Human Dimension programme aims to develop data

and methods for use in assessing the benefits and costs of enhancing terrestrial carbon sinks. It will also focus on assessing the influence of the invention and diffusion of new technologies on greenhouse gas emissions, and carbon sequestration research (USGCRP, 2002).

Table. 5.2: Total Funding for US Global Climate Change Research in Fiscal Year 1999

Scientific Research Agency	1999 FUNDING FOR GCR (million $)
Department of Agriculture	55
Department of Commerce/National Oceanic Atmospheric Administration	63
Department of Energy	114
Department of Health and Human Services /National Institute of Health	40
Department of the Interior / U.S. Geological survey	27
Environmental Protection Agency	17
National Aeronautics and Space Administration - science	240
National Science Foundation	182
Smithsonian Institute	7
TOTAL	**745**

(Source: IGFA, 2000).

Table. 5.3: U.S. Global Change Research Program: Fiscal year (FY) 2001 – FY 2002 budget by research program element by agency (discretionary budget authority in $ millions)

	NOAA science	NOAA Obs	DOE	EPA	NIH	NASA science*	NSF	SI	US DA	Total
FY01	44.6	9.0	70.3	0.0	0.0	61.9	100.4	2.0	0.0	294.2
FY02	44.8	16.3	70.8	0.0	0.0	61.9	92.4	2.0	0.0	292.7
FY01	7.8	1.0	12.6	0.0	0.0	55.9	16.8	0.3	18.1	112.5
FY02	7.8	1.0	12.6	0.0	0.0	54.1	16.9	0.3	18.0	110.7
FY01	5.7	0.0	0.0	0.0	0.0	56.3	10.3	0.0	2.8	75.1
FY02	5.7	0.0	0.0	0.0	0.0	56.6	12.7	0.0	2.8	77.8
FY01	4.8	1.0	12.7	0.0	0.0	46.7	16.0	0.3	14.8	100.3
FY02	4.8	4.2	13.7	0.0	0.0	47.2	21.5	0.3	14.8	109.5
FY01	0.0	0.0	12.4	3.0	0.0	32.8	30.1	3.8	20.8	119.9
FY02	0.0	0.0	12.4	2.0	0.0	33.2	30.1	3.8	20.6	116.6
FY01	5.6	0.0	8.0	20.0	51.6	0.0	13.7	0.6	0.0	99.5
FY02	5.6	2.5	8.0	20.0	57.0	0.0	13.7	0.6	0.0	107.4
FY01	68.5	11.0	119.1*	23.0	51.6	253.6	187.3	7.0	56.5	**804.7**
FY02	68.7	24.0	120.6*	22.0	57.0	252.9	187.3	7.0	56.2	**818.4**

Source: USGCRP, 2002

* DOE Totals include $3.1 million for Small Business Innovative research/Technology Transfer

*NASA observations not included

Funding for climate research in the US is distributed and co-ordinated through the US Global Climate Research Program (USGCRP), which supports climate research through 10 US federal agencies: National Science Foundation (NSF), Environmental Protection Agency (EPA), National Aeronautics and Space Administration (NASA), Department Of Energy (DOE), Department of Commerce/National Oceanic and Atmospheric Administration (NOAA), Department of Defence (DOD), Department of Agriculture (DOA), US Geological Survey (USGS), Smithsonian Institution (SI) and the National Institute of Health (NIH) (see Table 5.3) (USGCRP, 2002).

As noted earlier, President Bush plans to increase investments in climate research by $700m in total over the next 10 years. If global climate research funding in the US continued to increase at an average of 5% per year (the mean of fiscal funding 2001 and 2002), there would be a rise in the climate research budget of only $50m in total over the next 10 years. Thus, Bush's pledge raises this figure by 1400%.

5.3.3 Trans-Atlantic Comparisons in Climate Change Funding

The fiscal climate research budget is larger in the US compared to the UK. In the fiscal year 1999 the US spent 83% ($617.4m) more than the UK. However, additional funding for climate research in the UK is potentially available from the EU. The EU spent around 63m Euros ($61.9m) on global climate research in the year 2000. This rose to 72m Euros ($70.7m) in 2001, and it is estimated to reach about 81m Euros ($79.6m) by the end of 2002 (IGFA, 2000). Ultimately, the limited scale of EU investment in climate science does little to close the trans-Atlantic gap in funding, highlighting the relative strength of the UK governments' commitment to global warming research.

As noted earlier, funding systems in the UK and US are slightly different, even though both countries operate under economically liberal principles. This is perhaps most evident in the recognition that the US government spends more on preventative climate action, compared with the UK, which focuses more on climate research itself. Tables 5.1, 5.2 and 5.3 provide evidence of how much money is spent on the implications of climate change, such as preventative measures, rather than climate research *per se*. Seventy-six per cent of the 1999 government budget for US global climate research was

spent on applied thematic research, rather than basic science. Also, approximately 13% of the US 2002 budget will be spent specifically on the human dimensions of climate change, with each agency spending an additional amount on the subject. In the UK, however, roughly 66% of the 1999 budget for climate related research was spent on basic climate science (presuming that NERC carries out most basic climate research in the UK). This is a substantial contrast to the US, where only 24% of the federal budget is designated to basic climate work. The NSF, which undertakes the majority of basic climate work yet also undertakes non-basic work, does not operate independently from other councils. For instance, the DOE, in partnership with the NSF, is supporting an iron-fertilization experiment, a project that is focusing on mitigation through carbon sequestration (USGCRP, 2002, p.53). This suggests that some of the NSF's own money goes to non-basic work. In fiscal year 1999, NASA spent 32% ($240m) of its budget on global climate research, the greatest proportion of the total budget for any individual agency. The Smithsonian Institute spent the smallest share - 0.9% ($7m) - of the US global climate research budget.

Differences in the allocation of state funding are potentially reinforced by transatlantic differentials in the availability of support from commercial sources. Such funding is more available to climate research in the USA. In particular, Beder (1997; 1999) and Gelbspan (1998), Rowell (1996) have argued that fossil fuel companies are a significant funding source for US climate science, disproportionately encouraging the work of climate sceptics. However, the exact figures spent by corporate organisations are illusive. It is apparent that fossil fuel companies fund conservative think tanks which have a variety of agendas, including questioning mainstream opinions on climate change science. Although figures are available for the individual think tanks, none are obtainable for the amount spent on debunking global warming. The Heritage Foundation, for instance, has a budget of over $25 million per year, with the majority of its money coming from donations from corporations such as automobile manufacturers, coal, oil, chemical and tobacco companies (Beder, 1997). While a percentage of their funds would be directed to climate studies, it is evident from the broad scope of their donors that other issues are also addressed. It is therefore difficult to estimate a figure spent by industry on climate change.

Beyond these general comments about funding, further information about money distributions and the particular types of climate research that actually receives money, (for instance, the amount spent on climate modelling), is unavailable. Data detailing the overall amount spent on basic and applied research in both the UK and US are inaccessible. Thus, estimates can only be made about the extent to which each country is working towards preventative measures and actual climate research.

5.4 Climate Science: Funding and Pressure

5.4.1 Universal Pressure to get Funding

Since the 1970s there has been a change in the academic research environment in both the UK and the US leading to growing stress on the importance of output (publication), accountability, productivity and funding (Tudge, 1999; Tudge, 2002). In the UK, for example, there has been a recent modification to national policy which places new responsibilities on universities to account for their spending of public money. Research Assessment Exercises (RAEs) have been introduced to evaluate all university departments according to their input and output. Publications in prestigious journals, coupled with substantial income, earn higher ratings in RAEs. The importance of RAE ratings adds to the existing pressure from institutions on academics to obtain funding to remain at the forefront of rapid developments within science; to purchase equipment; and to support the necessary research staff, thus contributing to the rating of the university (US interviewee C, 2000). Gaining funding 'brings prestige to the university' (US interviewee D, 2000; US interviewee N, 2000). Consequently, there is universal pressure on scientists to obtain funding (UK interviewee J, 2000). Indeed, pressure to some extent, is self-imposed, as some academics try to secure funding for the research they themselves want to undertake. All interviewees recognised this pressure to get funding. However, there were some specific differences in how this was reported by particular respondents.

Within universities there appears to be more emphasis on individual responsibility for obtaining funding, rather than the collective process of bidding for funding. This contrasts with a more combined approach to research and funding evident amongst government scientists or institutions such as the Met Office. (UK interviewee G, 2000;

UK interviewee H, 2000; UK interviewee J, 2000). The latter reflects an emphasis on teamwork, rather than individual research within such bodies. Teamwork reduces personal freedom in order to secure a collective goal. There may be less individual pressure to produce research because any single individual is less accountable for the overall output (product). Thus, the pressure for funding, usually seen within a university context, also applies to government agencies, but in a slightly different form.

In the UK, tenured salaried scientists working within prestigious universities can apply for a wide range of research grants, including some which are inaccessible to scientists from less high-profile universities. Similarly, researchers working within high profile institutions such as the MIT in the US, were considered more likely to persuade grant awarding bodies of the prospective quality and value of their research. This was noted by a US social scientist interviewee whilst commentating on a particular scientist:

> I just very much doubt that he has any problem getting funding, he's at one of the wealthiest universities in the world and he's a professor…

Thus, scientists working within high status institutions may be under different types of pressure than those scientists researching in less well-known universities. Indeed, wealthier universities impose greater expectations upon their researchers. This quote also suggests that those scientists who are established and have a reputation find it easier to win grants (US interviewee D, 2000; US interviewee N, 2000). Personal and institutional reputations assisted them in winning grants. Perhaps, too, individuals enjoy a greater personal sense of security. Having reached the pinnacle of their career the immediate pressure to prove themselves is reduced (US interviewee D, 2000).

By comparison, younger researchers amongst the interviewees felt more vulnerable and under greater pressure to obtain funds than more established scientists. The competition among young researchers was explicitly noted by two UK protagonists. They stated that scientists were more dependent and felt pressured to obtain funds early on in their careers. Only in this way could they establish and prove themselves as good researchers within a reputable university and develop status within their research field (UK interviewee H, 2000: UK interviewee I, 2000). Without a concrete reputation and prestigious university backing it is harder to obtain money. Some grant awarding

bodies, such as the NERC, have recognised this as a problem and for over 15 years have budgeted funds specifically for young researchers who are just beginning their careers.

The interviewees highlighted a potential US/UK contrast in terms of the contributions made by funding to individual projects. In the UK only non-tenured researchers use grants to provide for their salary and research. UK scientists with a tenured university post usually earn a fixed salary from the Higher Education Funding Council (HEFC). However, if the scientist does not have a permanent HEFC position then they have to include provision for salary funding in their research grant application; a position that can only heighten their sense of insecurity. In the US, however, research funding may contribute to meeting the salary costs for tenured professors. Here, research funding pays some scientists' personal wage during the summer vacation, a period of around three months a year (US interviewee A, 2000). As one US sceptic points out this imposes equivalent pressures on scientists of all shades of opinion in climate research: 'sceptics are also dependent on funding in the US, not only for their professional research livelihoods, but also their personal income' (US interviewee N, 2000). The US participant expanded upon this point, explaining that:

> Most of us depend on research funding because it is some form of our salaries – two-elevenths – three twelfths of your salary, it is significant (US interviewee N, 2000).

Significantly, therefore, both protagonists and sceptics claim that funding is important to undertaking their work. A British protagonist highlighted how obtaining research grants becomes a major driving factor for good career prospects (UK interviewee J, 2000). This attitude was detected in all interviewees regardless of their present status, position on global warming, or nationality. They all stressed that scientists' livelihoods - which incorporated issues of personal pay, career, reputation and status (academic profiles) - are directly reliant on the degree of funding they personally obtain. Their professional livelihoods were also related to the number of publications that they produce (see Chapter Six). As Spier notes, 'performance of an academic is measured by successful and cited publications' (Spier, 2002, p.102). With such pressure upon scientists to attain funds, directed by their institutions and created by them, to what extent have UK and US scientists adapted their practice to achieve funding?

5.4.2 Funding and the Research Agenda – the Experience of Individual Scientists

As an ideal, science proclaims itself to be a universal quest for truths about the world (Sadar, 2000). This long-established model reflects an original conception that achieving comprehensive knowledge was possible for the individual scientist. Such understanding was supposedly accomplished, confirmed and extended through the means of objective observation, experimentation and analysis. It is still the case that scientific training advances the ideal of objectivity as the stamp of good scientific practice (see Chapter Three, section 3.2). A lengthy scientific education is ostensibly intended to produce individuals who are strongly committed to the values and norms of science. It is not surprising, therefore, that interviewees articulated this viewpoint and perceived themselves to be objective. One key statement of this was a profession of positivist faith in evidence and scientific truth:

> …scientists are only convinced by their scientific material and data (UK interviewee F, 2000).

Hence, the sole priority for some UK and US scientists is to research. As Monbiot notes, 'many researchers could be described as idiot savants, brilliant specialists, but neither trained or expected to see beyond what they are doing' (Monbiot, 1995, p.2).

The notion of the all-knowing individual scientist has been over-taken by our growing realisation of the sheer scale and complexity of scientific knowledge. Any one individual can, therefore, only aspire to understand a fraction of the total knowledge generated through scientific research. Modern science is, thus, structured by disciplines and sub-disciplinary specialisms (see for example, Chapter Four, section 4.3).

Moreover, the ideal of science as a search for universal truth offers little guidance regarding the direction of scientific research, either by individuals, or at a societal level. Thus, an individual might construct a rationale to determine the future direction of research which incorporates the random pursuit of topics, or a strategy determined by personal interest. In practice, however, precedence tends to be established that reflect internal and intellectual debate within science, or the identification of issues that seem to be of wider societal relevance. The latter attempts to recognise and prioritise 'useful knowledge', representing a departure from the scientific ideal. However, it could be

argued that an emphasis within science on the pursuit of useful knowledge is a necessary and a beneficial departure from the ideal of science, providing a focus and purpose to research and to justify the commitment of external funding to support science.

Pragmatic acceptance of the reality of scientific research and funding amongst interviewees is, therefore, to be expected. Many acknowledged that competition for funding often had an influence upon the identification and framing of research topics. Yet this was not seen as a betrayal of the ideal of objectivity in science, as the conduct of the research and the production of results preserved the initial commitment to truth and objectivity. This distinction between the necessary compromises to obtain funding and to adhere to objectivity was highlighted by one UK interviewee:

> I think most scientists are aware that most things that are found can be used in several ways. It doesn't mean it affects the work scientists do, I mean, most of them in their actual work, I'm sure, are objective; i.e. they see something and say what it appears to mean (UK interviewee K, 2000).

Moreover, academics routinely fine tune research proposals so they appear more relevant to funding bodies, even though their own individual research agenda may be slightly different. Interviewees unanimously agreed that funding prospects are improved through the inclusion of key, well-funded, themes within research proposals. A US interviewee claimed that this was a 'common sense strategy ... you try to get funding for work that is likely to get funded' (US interviewee D, 2000). Another respondent considered such behaviour as a consequence of the institutional structure of modern science: 'The way science is funded more and more forces them [scientists] to be like that, they have to compete for funding' (UK interviewee K, 2000). As a result, well-funded subjects, such as climate science, may attract proposals from opportunistic scientists:

> individual researchers try to get funding and realise that there is a lot of money in a particular field, [so they think] how can I tweak my research to help tap into that research fund. I think people do that all the time (US interviewee A, 2000).

A British interviewee also provided an example:

> I've been to meetings in Imperial College where scientists were doing some work on world sea temperatures and climate change, and someone said to him, 'That's a very small change you're expecting there' and he said, 'Well yeah, it is actually very small change', and then he said, 'Just between these four walls, I don't believe it is a very important change, I'm more interested in doing research in ocean temperatures generally, but I'll take the money for global warming research because that's where the money is (UK interviewee K, 2000).

Thus, scientists gain funding to investigate issues that personally interest them (but within allotted boundaries) and publish accordingly. Moreover, they are able to defend their actions in terms of scientific objectivity because their research results will be true to their experiments. Interviewees, therefore, rejected any suggestion that pressures to obtain funding had led them to compromise objectivity. Scientists, therefore, retain a degree of freedom and influence within the superstructure of society by framing their own research and shaping the direction of their work. Thus, scientific research is not totally determined by the economic substructure. Although society may shape research agendas, there is often sufficient flexibility for scientists to pursue their own interests (Tudge, 1999, p.53).

5.4.3 Collective Attempts: Maximising Funding for Climate Science

Individual strategies to gain funds exhibit a degree of commonality amongst scientists at all stages of their careers, including both the mass of bench scientists and the much smaller elite of eminent individuals. This supports perceptions that scientists can be individually calculating, 'opportunistic' and 'entrepreneurial' in an attempt to obtain research monies: 'if there is a funding possibility they will jump into it' (UK interviewee K, 2000). However, climate scientists may also act together to re-direct further funding for the issue as a whole. Collective efforts by scientists may enhance the public profile of their field, as a UK interviewee noted: 'anyone involved in any field will want to justify its continuation. So, the scientists will act together to justify continuation' (UK interviewee K, 2000). Indeed, protagonist climate scientists have been accused of over-emphasising and exaggerating the seriousness of global warming in a bid to justify additional financial support (Boehmer-Christiansen, 1994a and 1994b). Paradoxically, climate sceptics may also have contributed to this process through their repeated assertions regarding the uncertainty of climate science.

Past analysis of the process of bidding for funding for climate science has explored the construction of scientific influence. Boehmer-Christiansen (1994a, 1994b), and Hart and Victor (1993) observe the influential standings of a minority of high-profile and well-connected individual scientists. Other accounts argue that funding decisions are most influenced by the critical mass of scientific opinion highlighting climate change as a significant issue (Paterson, 1996a). All scientists have some insight into the nature of achieving funding for the issues, however, an influential minority play a disproportionate role in the direction of funding for climate science. They are active as referees for individual research proposals. They also form the funding boards that make higher level decisions about the distribution of support between research fields. Scientists who have such multiple roles are perhaps more knowledgeable about the institutional procedures involved and are more influential in directing further funding into the field of climate change (Daniel, 1993; Savage, 1999; Tustain, 2002). Indeed, the eminent UK climate scientist, former Chief Executive of the UK Meteorological Office and co-chairman of WGI of the IPCC, Sir John Houghton, together with Sir Crispin Tickell, former UK Ambassador to the United Nations, is credited with using his status and political connections to persuade the then Prime Minister, Margaret Thatcher, to establish the Hadley Centre as a British centre for climate research, in the late 1980s (Chapter Two, section 2.4.1). This example seems consistent with Hart and Victor's (1993) suggestion regarding the influence of a minority of well-connected individuals in advancing support for climate science. These individual scientists have high institutional profiles, greater access to policy-makers and others in positions of power, and, ultimately, themselves contribute to framing policy (see Mulkay, 1976).

Although the arguments of Boehmer-Christiansen (1994a and 1994b) and Paterson (1996a) are rather different, they similarly acknowledge the 'powerful' standing of, usually, mature protagonist scientists, with political connections, such as Houghton. They highlight the role that these individuals play as 'leaders' of groups such as the IPCC; frequently interacting, influencing and networking with policy makers. These scientists are almost certainly aware of their influence and are in a position to use it. However, Paterson (1996a) also argues that the collective embodiment of scientists acting together on their consensual beliefs, through prestigious organisations, are potentially more influential (see Chapter Two). It follows, therefore, that Margaret Thatcher's willingness to fund the Hadley Centre would have been much less without

the collective emphasis by protagonists regarding the importance of global warming and climate research as a whole. It is perhaps more likely, therefore, that it is the combined influence of both the mass of bench scientists and the high-profile scientific elite that affects research agendas and funding budgets. As noted above (see section 5.3.1), many bench scientists have a degree of influence in informing research councils and government bodies about research priorities. Efforts to persuade funders to allocate more money to climate science were noted by a UK protagonist interviewee:

> scientists like anybody else are very able to spot an opportunity for funding if it's in an area that they want to research in and they will emphasise it because they want to increase their chances of funding (UK interviewee G, 2000).

The recent increase in UK and US government funding for climate research appears to reinforce this argument, particularly in the US, where funding will increase by 1400% over the next 10 years (see section 5.3.2).

Collective efforts appears to characterise the seemingly opposed camps of protagonists and sceptics. Paradoxically, their continuing debate probably strengthens the case for funding climate science by reinforcing the notion of scientific uncertainty. On the one hand, sceptical scientists emphasise the failings of existing climate science and the potentially serious economic implications of climate change policy. This stance attracts organisations or businesses with a vested interest in debunking climate science, which may direct funds towards further research in this area. On the other hand, protagonists highlight the need for continuing research to confirm the seriousness of climate change. This involves attention to resolving the remaining uncertainties and to exploring the implications of climate change. Such arguments are intended to increase the pressure on governments to direct further funding to the issue. In both cases, however, the existence of scientific debate between protagonists and sceptics further strengthens the scientists' claims for funds.

At the same time there is conflict between the two opposing camps of scientists. Each accuses the other of bias, reflected in a willingness to compromise good science in the pursuit of funding. Moreover, the two sides claim that their opponents are uniquely 'corrupt'; while they themselves maintain scientific values of objectivity and truth. The

following section explores these allegations, investigating whether they are used to undermine the credibility of science and the scientists involved.

5.4.4 Debunking Climate Protagonists

Boehmer-Christiansen (1994a and 1994b) has been particularly critical of the actions and motives of IPCC protagonists, arguing that their stance is in part opportunistic, being driven by the desire to gain money for further research. This section explores such criticisms, setting them against the insights gained from interviews, especially those with climate sceptics.

Boehmer-Christiansen has advanced her argument through a series of papers, including material published under the auspices of the pro-market think-tank, the IEA (Morris, 1997). Essentially, she claims that many of the scientists associated with the IPCC are guilty of a 'bureaucratic imperative' in exaggerating the effects of climate change and the need to reduce the uncertainty that still surrounds much climate science (Boehmer-Christiansen, 1997, p.53). In part, this is argued to be a plan to strengthen the case for international action to combat climate change through implementation of the UNFCC. However, Boehmer-Christiansen also claims that scientists' are driven by other self-interested motives, principally that governments can be encouraged to commit additional funding to data collection and climate change research (Boehmer-Christiansen, 1994a and 1994b). Indeed, she highlights that one of the outcomes of the 1992 Rio Earth Summit was an additional investment in research, which satisfied the interests of climate protagonists (Boehmer-Christiansen 1994a and 1994b). Thus, she argues that there is a calculated conspiracy between protagonist IPCC scientists and other interests, including environmentalists and businesses promoting renewable energy technologies, to secure research funding that will disproportionately benefit those who argue for the seriousness of climate change.

Boehmer-Christiansen's case is well founded, although Shackley and Skodvin (1995) criticise Boehmer-Christiansen for claiming to know the motivations of the IPCC. The summary for policy makers that accompanies the 2001 WG1 report devotes a whole section to a call for further research, emphasising that 'further action is required to address remaining gaps in information and understanding' (Houghton *et al*, 2001, p.17).

It appears that protagonist scientists associated with the IPCC hope to convince policy makers and governments to direct increased funding towards climate research. Their motivation for doing so is probably two-fold: to advance what they see as a genuinely important issue, but also to direct more research funding into an area that will benefit them personally.

Boehmer-Christiansen's views and those of other external commentators are echoed in some of the criticisms of climate protagonists by interviewees from both the UK and US. Several claimed that the IPCC over-emphasised uncertainty over climate change in their 1995 report, in the hope of gaining more funding for the broad field of climate science. Thus a UK contrarian contrasted the sense of urgency displayed in the most recent IPCC publication with: 'One of their earlier reports [in 1995, which] ... was pretty prevaricative, waffling about whether there was decisive change (UK interviewee K, 2000). He also argued that protagonists are now emphasising the seriousness of climate change to direct more funding into the subject, as

> there isn't funding being offered around to people who are saying that there isn't a danger, don't do anything (UK interviewee K, 2000).

The tone and the content of IPCC reports appear to be important in preserving a high political and media profile for climate change. Similar charges were made by a US contrarian, who claimed that the 1995 IPCC report overstated the human capacity to modify the global atmosphere (US interviewee M, 2000). This interviewee also asserted that this stance was motivated by the desire of prominent protagonists to direct more money into global warming research, as well as to gain greater personal prestige and a higher media profile (US interviewee M, 2000).

Contradicting Boehmer-Christiansen's argument, yet at the same time, also criticising the IPCC, Seitz, the Global Climate Coalition (GCC) and other sceptics have accused the IPCC of fraud in the WGI IPCC report of 1995. They alleged that lead authors of Chapter Eight, had suppressed scientific uncertainty to pursue a political agenda (Edwards and Schneider, 1997; FOE, 2002). This suggests that some IPCC protagonists are not only interested in securing increased research funding for their field, but that they are also aware of the political ramifications of their work. Indeed, Paterson (1996a) claims that this political motive was of primary importance. He recognises that the

IPCC is goal seeking, but argues that the actions of its leading scientists primarily reflected their understanding of the potential seriousness of climate change and its likely effects upon society and the natural environment. It does seem to be the case that external political considerations influenced the content of the IPCC report. Indeed, the process is derived on consultative and open-peer review system, where there is 'negotiation and accommodation between 'legitimate' parties involved', thus creating a situation where it is possible for such manoeuvres to occur (O'Riordan and Jordan, 1999, p.78). Many lead authors seemingly wanted the 1995 report to contain a stronger statement about the potential for serious climate change, but they were over-ruled by governments as a result of heavy pressure from the OPEC countries and the GCC (Edwards and Schneider, 1997). As a result, the debate about the 1995 IPCC report has been marked more by assertions than proven fact.

Contrarians also criticised climate protagonists claiming that they individually tried to gain a larger share of the available funding for their own research. Hence, one of the prominent US sceptics claimed that since the politicisation of climate change many scientists throughout the western world have become involved in global warming research and have committed themselves to a protagonist stance because the issue is not only high profile and of societal relevance, but also because they are attracted by the substantial research funding available (US interviewee N, 2000). This was echoed by another US contrarian who noted that: 'some of the scientists find that it is remunerative to support the side that has the most money' (US interviewee L, 2000). Indeed, this interviewee went further, accusing protagonists of departing from the ideal of objectivity in the interpretation of their research findings. Allegedly this was a calculated attempt to obtain or maintain research funding. In particular, he suggested that the expense of operating GCMs had prompted some scientists to 'tilt the story in the direction that's most likely to give them money' (US interviewee L, 2000). Indeed, Wynne (1984, p.277) claims that GCMs are not 'objective technical frameworks'. Thus, they are perhaps open to ambiguity.

Such accusations are a serious charge against the integrity of climate protagonists. However, they are not necessarily to be taken at face value. Scientific interest in climate research perhaps reflects a genuine belief in the importance of the issue and the need for sound scientific foundations on which to build policy to combat climate change and its

effects. Nevertheless, funding is a contentious issue, especially as scientists face increasing personal and institutional pressures to obtain research funds. Contrarians' claims of protagonist opportunism are centred on the alleged ease with which funding can be obtained for such research. By comparison, several US contrarians asserted that their particular stance on climate change was a hurdle to gaining state funding. As a result of such alleged inequalities in the distribution of funding, some former climate sceptics may change their scientific stance. Since the interviews, the US has seen a change of government, with the election of a strongly pro-business, Republican President, George W Bush. It remains to be seen whether this results in a significant change in the funding profile for climate sceptics.

Although controversy surrounding commercial sponsorship of climate research has particularly revolved around the support given to research that is questioning of climate change, several interviewees pointed to the funding that is available to climate protagonists, to reinforce their charge of opportunism. This has echoes of Boehmer-Christiansen's (forthcoming) inclusion of the promoters of renewable energy amongst her climate 'conspirators'. Indeed, in recent years the mainstream energy industry has taken an increasing interest in alternative and renewable energy sources (Rowlands, 2000). Climate change is therefore presented as a profitable investment opportunity (Environmental Defence Fund, 2000; Mastio 1998; Tudge 2002). Indeed, government aid and sponsorship is often available to support commercial innovations in renewable energy (UK interviewee K, 2000). Energy companies may also perceive a new commitment to investment in renewables as a means of improving their public image by highlighting both their environmental credentials and their capacity to offer an effective answer to climate change (Environmental Defence Organisation, 2000; Mastio 1998; Tudge 2002; UK interviewee K, 2000). The change in attitude – which is also evident in the departure of a series of high-profile companies from the sceptical Global Climate Coalition over the past five years – may in turn affect the availability of commercial sponsorship for climate science. Again the claim is made that funding is driving science in ways that are at odds with a proper understanding of climate change. Some US energy corporations still appear to be willing to sponsor the production of scientific knowledge that challenges the seriousness of global warming. But their potential as a source of funding for climate sceptics seems to be decreasing. The most likely beneficiaries of any reallocation of research funding are not, however, climate

protagonists. Rather, the likely outcome of this change in commercial strategies involves a diversion of resources away from fundamental science, towards applied research in areas including sustainable energy (Rowlands, 2000).

The interviews disclosed a degree of personal bitterness amongst some climate sceptics at the alleged ease at which protagonists obtained research grants and other rewards as a result of their stance on climate. Individual animosity appeared to colour the arguments of some interviewees and their attempts to cast doubt on the ability and integrity of high-profile protagonists:

> If you go to scientist V [the interviewee names specific scientists], or scientist W, or scientist X, or scientist Y, each of them has collected in the order of a million [dollars] on Kyoto for being politically correct. The case with scientist Z, his earnings from talking about this exceeds his salary by a lot (US interviewee N, 2000).

These allegations are themselves hypocritical because such figures are earned by leading scientists on both sides of the debate. The interviewee himself has increased his own income by around $5,000 per year from lecture fees (Beder, 1999); although he legitimises this with the observation that it is far less than one of the leading protagonists referred to above who receives '$100 thou[sand] a year' (US interviewee N, 2000). Beder also notes that when prominent sceptics are commissioned by the fossil fuel industry they demand substantial fees, of the order of $2,500 per day (Beder, 1999, p.121).

The interviews display arguments common to UK and US contrarians, which are also often maintained by some social commentators and anti-environmentalists to delegitimise the practice of protagonist scientists and the IPCC. These views reflect and support the stance of organisations such as the UK-based IEA and SEPP in the USA. Both the interviewees and previous published studies (such as Boehmer-Christiansen 1994a, 1994b, 1996, 1997, forthcoming), however, concentrate on the alleged failings of their opponents and the willingness of some climate protagonists to compromise good science in order to win either funding for the field as a whole, or an individual advantage in the competition for funding and career advancement. Yet the suggestion that such suspicious practice is unique to climate protagonists is not sustainable. The

potential for tensions between scientific ideals and reality is equally evident amongst contrarian scientists themselves.

5.4.5 Debunking Climate Sceptics

Charges of bias against climate sceptics have been advanced by a number of social commentators including Beder (1997, 1999), Gelbspan (1998) and Rowell (1996). They argue that contrarian scientists have been 'purchased' by external groups with an interest in the climate change debate. In the light of such claims, this section will reflect on the ways in which interviewees discussed the stance and the practice of climate sceptics.

As noted above, sceptics often presented themselves as discriminated against in the competition for research funding from official and mainstream sources. A US contrarian explained that if research is interpreted as 'reducing the implications or the impact of global warming, you get your research funds cut off' (US interviewee M, 2000). However, this view was not universal amongst the interviewees. Most sceptic interviewees declared that all their peers were familiar with funding problems (US interviewee L, 2000). Sceptics alleged repeated problems of obtaining funding from state sources in the USA, including the NSF and the EPA. They believed that this was a result of discrimination, rather than any failing on the part of the researcher (US interviewee M, 2000; US interviewee L, 2000). Some interviewees specifically raised the political point that sceptical climate research would conflict with the agenda of the then Democratic Presidency led by Bill Clinton. They claimed that US government agencies, such as the EPA, were unlikely to present grants to scientists whose proposals ran counter to the views of the pro-environmental Vice-President, Al Gore (US interviewee M, 2000). One US interviewee appeared to be unique in his opinions regarding these perceived funding problems faced by contrarians. He proclaimed his success of obtaining research funding from government agencies throughout his career, emphasising that government agencies are willing to fund alternative research on climate change, because it contributes to healthy scientific debate (Chubin, 2002; US interviewee N, 2000). However, this interviewee is well established and well respected, and works within a prestigious university, thus making him a strong candidate for state funding.

A British contrarian endorsed similar opinions regarding the difficulty in obtaining state funding for contrarian research. He pointed out that government organisations provide funds for protagonist global warming studies, yet sceptics are forced to seek funds elsewhere, such as from industry or right-wing NGOs (UK interviewee K, 2000). He supported the American interviewees and provided an additional argument as to why governments are interested in funding only certain research perspectives on global warming:

> …all successive governments have got a strong belief in global warming for the tax raising power they can use with it and consequently funding research that opposes such polices would be unwise… we need global warming scares basically to justify more public transport and that's a good thing [.] (UK interviewee K, 2000).

This statement implies that some governments are influenced by considerations other than the potentially detrimental societal effects of global warming. Climate change is seen as a means to justify restructuring taxation and reinforcing environmentalism. Global warming could be used to legitimise heavier pollution taxes upon industries, as well as 'green' taxes for the general population. Governments may present a green image, such as charging for the use of specific roads as an initiative to try and decrease the number of cars on the road, claiming that it would reduce emissions of atmospheric pollutants that contribute to global warming. This is the situation in London where Ken Livingston has authorised plans to charge motorists for driving in the centre of London to lessen congestion and help 'reduce pollution' (Tempest, 2002). However, such legislation may not be as environmentally friendly as implied by the government. Indeed, Lord Birt has recently proposed putting fee-paying motorways next to existing ones, which would only encourage car use (Rusbridger, 2002). This counteracts Livingstone's efforts to reduce car use and supports the UK interviewee's suggestion regarding the government's motivations.

Recognising the supposed position that sceptics claim regarding their difficulties in approaching standard funding sources for research, it needs to be investigated how sceptics have reacted to their situation. The views expressed by the interviewees were diverse. Some highlighted that the difficulty in obtaining funding has supposedly forced some US contrarians to withhold their preferred scientific research on climate change.

Thus, they compromised their beliefs to be able undertake scientific research. This was noted by a US sceptic repeating words said to him by somebody else:

> ...underneath I'm on your side [the sceptics], but I would never dare voice it because the Science Foundation would cut me off' (US interviewee L, 2000).

This perhaps encourages some scientists to choose to work in other fields rather than climate change. It may also motivate some individuals to present a protagonist stance because of the greater individual funding opportunities and the supposed imbalance of research monies in favour of protagonist scientists (US interviewee N, 2000).

An alternative response to being denied state funding was to seek money from different sources, particularly businesses or NGOs. Sceptics legitimised this position by arguing that they are being forced to do so by the absence of state funding for contrarian research. A US interviewee supported this case, claiming that $2 billion are spent per year on protagonist directed research, in contrast to less than $1 million for sceptics (US interviewee L, 2000). Although the source of these figures are not clear, it is likely that the former figure is state money and the latter consists largely of private contributions. This opinion is consistent with the earlier point regarding ease of funding for protagonist science. Such a perceived deficiency in funding for climate sceptics creates greater competition between them, as well as making it harder for them to promote their scientific standpoint (US interviewee L, 2000).

With the apparently limited options for sceptics to gain funding, some of these scientists are probably under great pressure. Therefore they are willing to accept money from bodies that are most likely to allocate them funding, which are usually less traditional sources that have specific agendas within the politicised climate arena (US interviewee L, 2000). This is perhaps the case in the US where there is a greater willingness amongst commercial organisations to become involved in funding climate sceptics in order to help their agenda by blocking the implementation of the Kyoto Protocol and postponing any form of precautionary action (see Chapter Two). In turn this relates to the greater strength of contrarian opinion, the number of sceptics researching in the US and support for climate research from energy companies and other business sectors. Beder (1999) highlights the extent of commercial interests in deligitimising climate science. She notes how the *New York Times* reported on the American Petroleum

Institute documents that showed that fossil fuel interests intended to raise $5 million over two years to establish a Global Climate Science Data Center as a non-profit educational foundation to influence the media and public to recognise the uncertainties in climate science (Beder, 1999, p.119).

A number of social commentators, such as Beder (1999), Gelbspan (1998), Rowell (1996) and Karliner (1997), support these opinions, which is the core criticism against climate sceptics. They defend this position by criticising sceptics as being 'bought' by fossil fuel companies, pro-free market NGOs or think tanks to produce 'dishonest science' by playing up certain results, or even producing sceptical climate research, to assist in their agenda in condemning global warming science. Evidence demonstrates that US sceptics, Michaels, Nierenberg, Seitz, Singer and Ellsaesser have all received funding from oil companies, think tanks or anti-environmental NGOs. A detailed summary of their commercial sponsorship can be found in Beder (1997 and 1999). Proof of British sceptics accepting money from energy corporations is not available or perhaps does not exist. Gelbspan presents further supportive evidence of contrarians using scientific research to promote political ideals. He claims a pro-environmental social commentator, declared that a scientist from republican think tank, the George C Marshall Institute (GCMI), used his/her scientific ability and influence to promote the political position of the GCMI. The Institute supports the views of five extremely conservative foundation supporters and has subsequently produced many reports dismissing climate change (see website for the George C Marshall Institute) (Gelbspan, 1998). This implies that this grand sounding 'foundation' is really just a front for a handful of individuals, who established an institute to make their arguments sound official, appear professional and have greater influence upon political agendas such as the Kyoto Protocol. As noted in Chapter Three, the IEA is a UK based think-tank supported by industry that aims to argue against conventional climate change policy, as it is opposed to regulation and state intervention. Although their uptake of the issue is political, like the GCMI, science has become a means to uphold arguments which are essentially political and support business interests. A US sceptic's economically liberal attitude was reflected in his comments about energy. Some sceptics strongly believe that because fossil fuel energy is very important for the functioning of a modern economy, implementing Kyoto, which will increase the cost of fuel, may trigger a recession (US interviewee L, 2000). The Republican think tank 'The National Centre for Public Policy

Research', estimates that stabilising greenhouse gas emissions to their 1990 levels by 2010 would slow US Gross Domestic Product by nearly 1%, and reduce income and wages by between 5 and 10% per year (Yohle, 1999). An economic firm, DRI/McGraw Hill, projects that reducing greenhouse gas emissions to their 1990 levels by 2010 will cost 500,000 jobs per year for a decade, resulting in a total of loss 5 million jobs (*Ibid.*). WEFA (formerly Wharton Economic Forecast Associates), has also predicted dire economic consequences if Kyoto is implemented. However, the predicted economic consequences described by such anti-environmental or anti-Kyoto organisations, depends upon the emphasis that underlies their respective models. Thus, data from pro-environmental NGOs suggests that implementing Kyoto will actually create jobs.

Some protagonist interviewees, however, made exactly the same charge against their sceptic counterparts. They accused sceptics of deliberately seeking individual funding from alternative sources for a political agenda. Collectively, UK and US protagonists accused contrarians of being influenced by organisations or companies which have specific interests in deligtimising the protagonist viewpoint: '…some sceptics are in the pay of particular people, and obviously they can be bought' (UK interviewee F, 2000). This interviewee's opinion was supported by other protagonists, suggesting that strings are attached to research monies that force scientists to influence or emphasise certain results and thus provide further support or legitimacy for the funding body's viewpoint.

On a similar note, a US protagonist claimed that Patrick Michaels, a vocal US contrarian, is in the 'pocket' of organisations with vested interests against climate legislation (US interviewee B, 2000; Beder, 1999). He asserts that he produced tainted research in accordance with the organisation's agenda. Yet, Michaels choice to work for anti-environmental NGOs implies that he supports their principles. Indeed, he is an advisor to many anti-environmental groups (Beder, 1997). This suggests that Michaels has a political opinion on the climate debate, which he supports with his scientific stance. Therefore, it appears that some sceptics may use their scientific research to express and emphasise their political viewpoint, thus going beyond the accepted boundary of 'objective' Western science. The integrity of these scientists is, therefore, questionable when their political ideals or opinions actually effects the research they undertake.

Sceptics retain a different account of their practice. They claim that they are not bribed to hold their stance; rather they see their manoeuvres as pragmatic, accepting funding from other sources because they are denied state funding. Indeed, the limited funding that goes to sceptic research is still dwarfed by state funding for protagonists. Sceptics believe, therefore, that they are not compromising their objectivity, but are warning against unnecessary action on climate change that would impose real economic penalties. A US sceptic referred to the alleged difficulties and imbalance of state funding for climate sceptics, claiming that his colleague had been 'dried up' and therefore forced to accept money from sources interested in promoting the contrarian viewpoint (US interviewee M, 2000). As noted earlier, the terms of confidentiality related to commercial sponsorship harbours the opportunity for sceptics who assert growing pressures in obtaining grants, to distort the scientific process and deliberately misrepresent research results as a means to continue to receive funding. Thus, there is the potential for climate sceptics to cross the threshold from an acceptable departure from the scientific ideal to biased or corrupt research focused on achieving future individual research funding. In such cases, commercial support reinforces the assertions that: 'it is, of course, nonsense to assert the value-freedom of natural science. Scientific practice is governed by norms and values generated from an understanding of the goals of scientific enquiry' (Longino, 1990, p.4). 'External' investment for sceptics, however, may help to maintain healthy scientific debate about the climate issue, which could otherwise be quashed.

Reflecting on these various claims suggests that some sceptics are perhaps not so concerned about gaining grants, but more interested in using their stance to portray a political perspective. Other sceptics do find it difficult winning state funding and therefore seek alternative sources of sponsorship. Business and NGO funding for sceptics is, however, more available in the US than in the UK by all accounts. As a result, the scientific playing field is perhaps more level in the USA. Indeed, the political context has changed in the US since the interviews were conducted. The Republican administration elected in 2000 may be more sympathetic to sceptical research. As noted earlier, government agents refuse to implement Kyoto, yet indicate a degree of commitment to combating climate change by directing more money into climate research. This money may fund contrarian research. Indeed, the largest share of US state funding on climate is distributed to NASA, which is chiefly devoted to funding satellite

data. Their research frequently contradicts climate models. Such data has, therefore, been used by climate scientists, such as Dr John Christy, who has worked alongside NASA's Dr Roy Spencer, to question the seriousness of global warming (see for example, NASA, 1997). As a result, protagonists' allegations regarding the financial benefits gained by adopting a contrarian stance may therefore be correct: [t]he real way to increase your funding is to say that climate change isn't happening' (US interviewee C, 2000), which is precisely the opposite of what the contrarians interviewees implied

5.5 Conclusion

The ideal of science proclaims an objective search for universal truths. However, the attitudes expressed by the UK and US interviewees reflected a reality in which most climate scientists, regardless of their stance or transatlantic position, depart from the scientific ideal when individually tailoring research projects to give them the best opportunity to bid for competitive funds. Paradoxically, the continuing debate between climate contrarians and protagonists itself helps to sustain funding to the field of anthropogenic climate change. Reflecting Hart and Victors' (1993) claim, elite scientists are, however, more influential than bench scientists in this role as they are referees and editors, as well as being familiar with institutional processes. Yet, their efforts are reinforced by the support of bench scientists (Paterson, 1996a). This critical mass confers its own legitimacy upon individual's claims of the importance of climate science.

This implies that scientists have a degree of influence within society and the substructure does not dominate politicised science in totality. Yet, climate scientists are still affected by societal pressures, as one interviewee noted:

> I don't think there's any such thing as neutral research anywhere. All research takes place in a context, and the research that was done depends on economic necessities. There's all sorts of research I would like to do [but]...no ones going to pay me for that (UK interviewee K, 2000).

Thus, the Polanyi (1962) and Mertonian (1973) models which portray science as a sphere totally separate from wider society seem naïve. This view was endorsed by a number of UK and US interviewees who acknowledged that the reality of contemporary

politicised science was a long way from the ideal of a neutral scientific search for truth. This does not necessarily mean that scientists who undertake research that has direct political consequences are influenced by the wider context of their work. Indeed, recognising that scientists are under pressure to gain funds for research, and that relatively generous funding is available for climate research from UK and US government agencies, it is not surprising that individual researchers try to define proposals in a way that will maximise their chance of funding. However, if scientists go further than this, deliberately misrepresenting their research in pursuit of financial gain or political ends they risk calling into question the integrity of their discipline. Within politicised science, where scientific results have potentially huge political, economic and social consequences, there is perhaps a greater tendency to go beyond the boundary that separates accepted manoeuvres to obtain funding for research, from less legitimate behaviour, including the use of research to obtain grants, or advocacy of a particular political perspective to attract external sponsorship.

Each camp of scientists accused the other of bias, compromising good science for funding or to push a political position, thus undermining the credibility of science and the scientists involved. They alleged that their opponents were uniquely 'corrupted', yet they themselves are pure and moral. UK and US sceptics universally claimed that protagonists received a disproportional amount of individual funding simply as a result of their stance on climate change. Sceptics claimed that they themselves were alienated and discriminated against in competition for state funding, both in the UK and US, thus forcing them to seek alternative sources of funding from the commercial sector or corporate organisations. If, however, the Bush administration does increase funding on climate research by $700m over the next 10 years, this may significantly change the funding profile for climate sceptics in the US.

The sceptic transatlantic interviewees echoed Boehmer-Christiansen's (1994a and 1994b, 1995, 1997, forthcoming) argument, claiming that IPCC protagonists emphasised uncertainty and the seriousness of anthropogenic climate change to gain further funding for the issue. One UK sceptic uniquely claimed, however, that protagonist scientists have the opportunity to gain individual funding from corporations which are promoting and establishing sustainable development. Such companies appear to be re-presenting themselves as having not just a green image, but also practical

solutions to environmental problems. They are attempting, therefore, to convince governments that they should provide the necessary funds to help other businesses make a similar transition to sustainable energies and create a more competitive market (UK interviewee K, 2000).

UK and US protagonists reflected the views of commentators such as Beder (1997, 1999), Rowell (1996) Gelbspan (1998) and Karliner (1997). They collectively claimed that sceptics advanced their stance and used their research to continue to obtain funding from fossil fuel companies. They also unanimously agreed that some sceptics have a particular vested interest in promoting their scientific standpoint as a means to gain support for their political position. For instance, George C Marshall Institute scientists were seen to have vested interests in advancing their Republican anti-environmental agenda through their scientific research.

The line of argument provided by Boehmer-Christiansen (1994a, 1994b, 1995, 1997, forthcoming) and the views expressed by Beder (1997, 1999), Rowell (1996) Gelbspan (1998) and Karliner (1997) reflect a partial analysis of the practice of climate scientists. Indeed, Shackley and Skodvin (1995) specifically claim that Boehmer-Christiansen's view is one-sided. They can all be criticised, therefore, for underplaying the collective manoeuvres of both climate sceptics and protagonists. The literature would also benefit from greater consideration of the various positions of climate scientists and how they relate to policy production.

Allegations regarding western contrarian and protagonist scientists raise questions concerning the credibility and integrity of some climate scientists. They suggest that within modern science some scientists may be deliberately crossing the threshold of integrity in their use of climate science as a means to either gain funding or to promote political perspectives. Hence, the interviewees' assertions have serious implications for the reliability of climate science as a whole, as well as other politicised scientific areas.

CHAPTER SIX

Scientific Output: The Academic and Non-Academic World of Publishing

6.1 Introduction

Funding (input) for climate research cannot be investigated without examining publishing (output). This chapter, therefore, balances Chapter Five, and examines the internal (academic) and external (public, mass media) world of scientific publishing. The processes of knowledge production and dissemination of research, in turn, help to justify further research funding. State funding for research is warranted through the production of new knowledge and its dissemination in published form; traditionally through academic papers, but also books and in some disciplines the popular press, TV and the Internet. Commercial or contract research is more likely to be produced for a specific target audience, and the means chosen to reach this audience may be rather different; involving unpublished reports and project briefings.

The first half of this chapter examines the stated purpose of the peer review process, based upon interpretations of the system as applied to all academic publishing. Attention then turns more specifically to the experience of climate science, investigating the possible influence that climate scientists obtain within the global warming debate through publishing their research within academic circles. This leads on to consideration of the extent to which academics as experts may gain influence based on their ability to publish and to control what others publish through refereeing. By examining interviewees' perceptions of the peer review system, this section investigates the reality of the process and compares it with the ideal. Particular attention will be paid to the following questions:

- To what extent does academia perceive peer review to create a system that potentially encourages, or at least allows, bias and prejudice, despite the initial aim of ensuring high standards and the objective review of work?

- To what degree does the process provide some scientists with influence as the gatekeepers of what is published?

- To what extent does authority gained through peer review give scientists influence over funding and/or the policy process?

This section concludes by investigating the possible implications of the reality of the peer review process.

The second half of this chapter analyses the mass media as an alternative or complementary outlet to peer-reviewed academic publications. The underlying theme of this section is the relationship between UK and US climate scientists and the mass media. It investigates the motives of those climate scientists who seek a media platform from which to put forward their views.

6.2 The Peer Review Process

6.2.1 The Peer Review Process as an Ideal

A formal process of peer review can be traced back to 17th century. Then, as now, it was a system implemented to ensure high standards of publication (Chubin and Hackett, 1990; Daniel, 1993; Hirschman, 1994). However, the modern day process originated in post-war America, where it became common practice in the production of scientific knowledge. Peer review refers to several related processes: the review of proposals for research funding; the evaluation of ongoing or completed research projects; the evaluation of teaching; and the review of manuscripts for publication in academic journals (Berg, 2001; Lee, 1997). Chapter Five considered the peer review process in relation to research funding; this chapter, for the most part, is concerned with the last in the list of contexts: peer review as a means to publication in academic journals. Publication in academic journals is the major international mechanism for disseminating and producing scientific knowledge.

Editors of academic journals – who are usually themselves senior academics – oversee the review process. It is they who choose referees to review academic papers for the

specific journal with which they are associated. There is rarely any formal institutional association between referees and particular journals; referees are chosen on an individual basis because their expertise is relevant to a particular paper. Although referees are not paid for their reviews, their position carries a degree of prestige and reflects an acknowledgment of their expertise that may help, indirectly, to advance their careers. Editors and reviewers judge papers against generic guidelines, such as originality, coherence of argument, standard of presentation, integration into existing scientific debate and contributions to that debate, and reliability of methods, data and other evidence (Berg, 2001; Daniel, 1993).

There are two main processes involved in refereeing articles for publication in academic journals. The first involves the editor who receives the manuscript and is the ultimate judge. The editor has several options: 1) to return manuscripts to the author without a review; 2) to send the manuscript out to reviewers directly; 3) to send a manuscripts to a member of the journal's wider editorial board, either for initial evaluation or full review – the initial evaluation may – or may not – lead to the manuscript being sent on to an external reviewer. Reviewers, chosen by the editor, judge the manuscript (Gura, 2002,) and have four basic options to advocate: 1) acceptance without revision; 2) acceptance with minor revisions; 3) rejection with an invitation to resubmit after major revisions; or 4) outright rejection (Berg, 2001).

Peer review is supposed to reinforce the quality of published science. It is the method imposed to measure the value of publications. As Aisen (2002, p.viii), notes:

> We need to hold ourselves to the highest possible scrutiny and only accept that evidence that can stand up to the closest of scrutiny.

Thus, the process is intended to filter out substandard or unoriginal papers, as well as articles where the claimed 'objectivity' of science has been fatally compromised. Longino (1990) claims that the process aims to ensure that authors have interpreted the data in a way that is free of their subjective prejudices. The peer review process was established to extend the scientific method to the review process itself, by judging academic papers 'objectively'. In theory, therefore, peer review is a 'mutually beneficial system that provides effective quality control in publication (Dalton, 2001, p.103). It also helps to improve the readability and quality of the article in question (Spier, 2002). Thus, once a paper is published in a journal it bears the stamp of authenticity from

editors and referees (Ziman, 1968). However, Longino point outs that publication of peer reviewed work 'does not [of itself] make an idea a brick in the edifice of knowledge' (Longino, 1990, p.69). Indeed, few papers that are published in journals are widely cited or read, and most, therefore, make little impact within the academic community.

Referees of papers are usually anonymous and equally authors' names are invariably removed from the manuscript before they are sent out for review. This reflects the belief that anonymity provides protection for both reviewers and authors. For example, it provides the opportunity for junior academics to comment on work by more senior colleagues. Furthermore, it allows reviewers to express criticisms about publications without feeling compromised by friendship or other associations (Bondi, 1998). Anonymity is thus identified as a means to ensure impartiality and objectivity and to prevent bias or subjectivity. Berg (2001, p.514) presents this process as follows:

> Objectivity = impartiality = disembodiedness = anonymity.

This model 'relies upon an older, masculine model of "objectivity" that is disembodied [and] impartial' (Berg, 2001, p.511). However, the reality of the academic peer review process is often perceived to be different. The subjectivity of academic scientists involved in the publishing process has led researchers to question scientists' integrity. For example, according to Berg (2001, p.512), the 'objectivity' that underpins the anonymous refereeing process is 'false'. Furthermore, Symanski and Pikard (1996) detail the subjectivity involved in the system. They claim that:

> Everyone has agendas and prejudices, and some people not only dislike certain members of their profession but may also be quite prepared to apply their agendas and prejudices against those whom they dislike; and (2) people vary immensely in their willingness to be honest with themselves and with others…

Thus, it is important to consider how the process potentially provides academics (editors, reviewers, as well as authors) with a degree of influence that has particular implications for what is published and considered to be knowledge.

6.2.2 The Reality of the Review Process: The Influence of Gatekeepers

The following section explores how the design of the peer review process relates to its aims. It considers the criticisms and doubts expressed regarding the process, underlining how the system can be abused in relation to discrimination against certain individuals, viewpoints and, indeed, whole sections of academia, such as women. This section investigates the influence that editors, referees and authors can have over the review process and the implications that this has for claims of objectivity.

As noted earlier, the peer review process is a system organised and controlled by academics themselves to assess the credibility of their work. Academics, therefore, have many roles; they are not solely researchers, but potentially the gatekeepers of future knowledge (Daniel, 1993). Individuals will, on different occasions, be involved both as author and reviewer. Authors of papers themselves play an active role in the peer review process, not least in deciding which journal to send their paper to. This reflects judgements as to the quality of journal, its kudos and circulation, but also the likely sympathies that editors and reviewers will have for the particular piece of work. It is apparent, therefore, that authors have a perceived degree of influence if they decide to publish papers. Equally, authors may choose not to publish their research because the results are not sufficiently interesting, or the project has produced null results. Although such work may be valuable, it is displaced by research that seems more interesting and publishable.

Individual researchers, therefore, choose whether or not to publish their work and aim to consign it where it will be most sympathetically received and make the most impact. However, as noted earlier, journal editors and referees police the system and ultimately determine what gets published. Potentially, therefore, they have more influence over what gets to count as knowledge. Indeed, Berg notes how his position as a peer reviewer gave him a degree of 'power' over the subject (Berg, 2001). Longino (1990, p.68) concurs that 'The production of scientific knowledge is crucially determined by the gatekeeping of peer review'. Yet referees are rarely called to account for what they write in reviews (Davidoff, 1998). Consequently, the accusation has been made that 'referees are able, with relative impunity, to delay or deny funding or publication to their rivals' (Goodstein, 1995, p.618). Thus, it appears that the influence which gatekeepers possess can be used to abuse the peer review system.

Chubin argues that 'innovative work survives because of its intrinsic merit: it succeeds as people become familiar with its advantages and prospects' (Chubin, 2002, p.109). Many others, however, take a more jaundiced view. Spier, for one, considers that the peer review system acts to reinforce the scientific status quo as referees resist significant departures from the dominant paradigm and 'the introduction of that which is deemed foreign' (Spier 2002, p.101-2). Similarly, Gura claims that 'good work is rejected because it clashes with reviewers' own studies and opinions – or simply because the ideas expressed are "too left-field", or perhaps … too right-wing' (Gura, 2002, p.258). The anonymous refereeing process 'provides a good opportunity to belittle the work of another through apparently "objective" attack on the merits of a manuscript', for referees 'are more willing to make use of their agendas and prejudices if their identities are concealed' (Symanski and Pickard, 1996, p.177). In practice too, anonymity is often one sided; reviewers are often able to identify an author through knowledge of their prior work and the citations included in the manuscript (Davidoff, 1998; Wessely, 1999). As a result, some scientists are discouraged from even submitting papers for peer review because they believe it to be an 'enormous waste of scientists' time' (Roy and Ashburn, 2001, p.393).

More worrying still is the evidence that the peer review system can be used as a tool to discriminate systematically against certain viewpoints, or groups of authors, not least as defined in terms of gender. Wennerås and Wold (1997) note the massive gender bias in the peer review of research grant applications to Sweden's Medical Research Council. Ives, too, explains that out of 114 applicants for postdoctoral fellowships, those successfully elected included 16 men, but only 4 women. Even taking into account the gender inequality in the pool of applicants 'women were only half as successful as men' in the final competition (Ives, 1997, p.1). This study, partly based on scientific competence, highlighted that women have to be 250% more productive through publishing to receive the same competence scores as men (Ives, 1997). Berg also observes the systematic discrimination against women who submit papers or funding proposals for peer review. However, he also specifically notes that within the field of geography reviewers are 'bourgeois, white Anglo-American, heterosexual, able-bodied and masculine', which encourages a degree of supremacy by such individuals and discrimination against those who do not fit the model (Berg, 2001, p.517). Moreover, the leading academic journals are predominantly under the editorial control of

Europeans and North Americans; as a result it is common for manuscripts from developing countries to be discriminated against (Berg, 2001). More specifically, articles or grant applications from 'Ivy League' and 'Red Brick' universities are frequently rated higher than, or published over, those from unknown universities, regardless of quality. This was noted by Longino who points out that scientific papers 'in at least one discipline were accepted on the basis of the institutional affiliation of authors rather than the intrinsic worth of the paper' (Longino, 1990, p.68).

The abuse of peer review by editors and referees is also evident in the tactics sometimes employed whilst reviewing manuscripts. Dalton notes that reviewers may be deliberately slow in responding to authors if they wish to delay a rival's paper (Dalton, 2001). This may occur because the reviewer has a competing manuscript under review elsewhere. More generally, scientists complain about manuscripts being deliberately stalled in review until similar findings emerge in other journals. Editors or reviewers may also plagiarise articles which they decide not to publish. Such problems are usually a result of the intense pressure to use publishing as a method to increase researchers' career profiles (*Ibid.*). Researchers also express concerns about leakage of information during the review process. In particular, they worry that reviewers who also act as commercial consultants may have privileged and premature access to information that should remain confidential. This access may be exploited to enable the businesses with which they are connected to obtain a commercial advantage in developing or marketing new products and processes (*Ibid.*).

Dissatisfaction with the established model of peer review has led to subversion of the process and a search for alternative means of publishing and dissemination (Roy, 1985). Recently, the internet has opened significant new possibilities for electronic publishing. As a result, an author can communicate with and receive comments on articles from thousands of people (McCarty, 2002). The internet also allows more work to be disseminated when publication in well-known journals is extremely competitive and very slow. Indeed, there is often a significant delay of 12 to 18 months between the acceptance of a manuscript and publication. For example, the prestigious international journal, *The American Psychologist*, receives more than 350 submissions per year, and has a rejection rate greater than 90% (McCarty, 2002). Thus, the internet provides an important alternative avenue for authors to circulate their research.

6.3 The Peer Review Process as it Relates to Climate Science

6.3.1 Climate Scientists' Reflections on the Publishing Process

Scientists and academics generally, have a vested interest in publishing articles to advance their careers and university profiles, and to help secure further research funding. As Spier (2002) notes the performance of an academic is measured by successful publications. However, individual scientists' reasons for publishing may vary, ranging from a belief in a moral duty to disseminate knowledge to a wider audience, to a desire to convince other academics of their perspective, and a personal desire for prestige. At the same time all academics face institutional pressures to publish their research. Indeed, the profiles of academic departments under review systems such as the UK RAE's, are largely assessed on the collective number and quality of their publications (see Chapter Five, section 5.4.1). Thus, academics are pressured to target prestigious (international) journals and are frequently directed to produce a certain number of published articles each year.

The pressures and incentives to publish were clearly recognised by the interviewees involved in the present study. As one UK interviewee emphasised 'my boss would look at me and think that I was bit second rate if I hadn't published in the *Journal of Climate* (UK interviewee F, 2000). But equally it was acknowledged that productivity brought rewards; professorships and other senior positions went to those who had 'brought in quite a bit of money and written quite a lot of papers' (UK interviewee I, 2000). Less senior academics also realised the importance of publishing peer-reviewed articles to advance their careers (UK interviewee J, 2000; UK interviewee K, 2000). It appears, therefore, that the career incentives to publish in academic journals hold good at every stage of the academic ladder. This may lead some scientists to research in 'fashionable' subject areas, in the belief that this will enable them to generate a steady stream of high impact papers. As one interviewee suggested initial idealism may become clouded by more self-interested objectives:

> Most of them [climate scientists] started off thinking they wanted to publish things, and then after a while they probably think money and career is more important. These things are bound together usually; the more you publish the more career prospects and the more funding (UK interviewee K, 2000).

The possibility of some scientists being motivated to publish for career purposes, and potentially to generate future funding seems at odds with Polanyi's (1962) model of objective science, and the ideal of science in general. However, as noted in Chapter Five modern science encourages scientists to consider their research environments pragmatically. Yet thinking in this way can become problematic, leading to questions such as those outlined above about the integrity of the peer review process. Scientific reputation and credibility, gained through reviewed publication, is particularly significant when an issue is controversial, uncertain and policy relevant. Thus, in the light of general concerns about biases in the peer review system, we must consider whether particular shades of opinion in the climate debate are subject to systematic discrimination.

The following section examines the perceptions of UK and US climate scientists about the peer review process. Claims of censorship in the process are explored alongside the potential for the system to be used to gain influence in the scientific world and policy arena. The discussion also considers whether scientists use their influence as gatekeepers not only to control what is published in the field of climate science, but also, as a result, to influence the allocation of funding for both the broad field of climate change research as a whole and for individual projects.

6.3.2 Perceptions of Bias Against Viewpoints and Researchers

All bar one (US interviewee N, 2000) of the contrarians interviewed argued that they and their fellow sceptics were discriminated against in their efforts to secure publication of their work and opinions. As one US contrarian put it, they are 'pushed out' of the publication system (US interviewee M, 2000). According to a sympathetic UK commentator this reflected the character of peer review as 'a corrupt process… because it relies very heavily on the status quo, people in there want to defend their own positions…. [Hence,] it appears a rather conservative process' (UK interviewee S, 2000). Sceptics claimed, therefore, that protagonist arguments dominated the mainstream scientific literature as a result of their own papers being marginalised or excluded. Certainly, by comparison climate protagonists displayed no collective sense that the peer review process was fraught with difficulties. Newald's arguments may help account for these differences. He claims that by challenging the status quo, contrarian authors ultimately undermine the case for continued funding in a particular research

field (Newald quoted in BBC, 1996). Similar thoughts were expressed by a US commentator who asserted that:

> peer reviewers, the entire … social system of science tends to prefer things that are at the cutting edge of recognised areas and not things that are trying to innovate theoretical foundations, unorthodox paradigms or whatever (US interviewee Q, 2000).

This leads, therefore, to questions regarding the logic behind the perceived systematic discrimination by journals against contrarian scientists. The pressure upon all academics to publish and secure research funding creates an extremely competitive environment. This is compounded by the specific controversy that surrounds climate change as an issue, creating particular struggles between certain viewpoints both for academic credibility and influence within the policy arena. This perhaps provides an enhanced motive for the climate protagonists, who form the scientific majority, to attempt to discredit sceptic viewpoints. Protagonists may seek to strengthen their own credentials as credible scientists and policy advisors by discrediting sceptic viewpoints. It seems important, therefore, to explore further sceptics' claims of prejudice, by investigating the presence of the contrarian voice in academic publishing on anthropogenic climate change.

Table 6.1 – derived from a Web of Science search – highlights the successful record of publication of papers relating to anthropogenic climate change achieved by six prominent US sceptics in some of the most prestigious international journals over the last 20 years. For comparison, material about the publication record of six UK and US prominent protagonists was also extracted. As noted in Chapter Three, identifying UK climate contrarians proved difficult, thus the table only provides examples of US sceptics. Identifying prominent climate scientists, those who had a degree of media involvement, provides a more consistent contrast between the two opposing camps, considering that most climate sceptics communicate with the media.

Table 6.1 Academic publications on climate change: papers by prominent sceptics and protagonists in *Nature*, *Science* and the *Journal of Climate*, 1982-2002

Climate Scientist	Journal			Total
	Nature	Science	Journal of Climate	
Sceptics				
Balling, RC	2	3	2	**7**
Michaels, PJ	1	1	0	**2**
Lindzen, RS	2	2	3	**7**
Nierenberg, WA	1	2	0	**3**
Seitz, F	5	1	0	**6**
Singer, SF	3	12	0	**15**
			Total	**40**
Protagonists				
Houghton, J	13	7	0	**20**
Hulme, M	5	0	5	**10**
Santer, BD	4	4	3	**11**
Schneider, SH	14	6	0	**20**
Shine, K	1	2	4	**7**
Wigley, T	29	5	2	**36**
			Total	**104**

The table highlights that sceptic climate scientists have produced around 62% fewer papers compared to protagonists. The number of sceptic publications in these leading journals was substantially increased by the contributions made by Singer, who produced, on average, twice the amount of papers than most other sceptics. The total number of papers by sceptics is perhaps reduced by the few publications contributed by Michaels. One explanation for this difference is related to the career stage of these two individuals. Singer is retired, yet still publishes papers, whereas Michaels is only part way through his career. It is, therefore, clearly not the case that contrarian opinions are excluded from publication in leading journals. This sample suggests, however, that

sceptics do publish fewer papers in leading academic journals compared to their counterparts.

The evolution of thinking about climate change itself reveals evidence of the significant contributions that leading climate sceptics have made through their reviewed publications. For instance, Patrick Michaels, a notorious US sceptic, recognised the potential importance of omission of sulphur in models of atmospheric processes. Michaels (1991b) suggested that sulphate smog emanating from industrial areas was cooling the atmosphere over sufficiently large areas to mask global warming. Developments of this work – plus other research by the same author – have been published in prestigious journals (Michaels 1996b, 1994, 1993). This theory forms the basis for Wigley's argument that reducing emissions of sulphur dioxide (SO_2) – the main source of sulphates in the atmosphere - might exacerbate global warming (Wigley, 1999). Such innovative work by sceptics compelled climate modellers to reassess GCMs and incorporate this missing substance. This has resulted in various GCMs across the world producing similar readings, and has made them the dominant tools in suggesting future climate change (Pearce, 1997; Shackley *et al*; 1998; UK interviewee F, 2000). Furthermore, Budyko has also helped to improve carbon cycle models by emphasising the benefit of CO_2 fertilisation upon the growth of plants (Budyko cited by UK interviewee F, 2000).

Overall, it seems that sceptics' claims of difficulty in getting their work published may be as much a reflection of individual grievances as they are of any systematic discrimination against their viewpoint as a whole. Indeed, the comments offered by protagonists regarding sceptics' concerns suggested an eagerness to debate with, and be challenged by, others holding different views. This was particularly well expressed by a UK interviewee:

> you can see that in the journals, usually in an article where there is some criticism and there is quite often a series of responses and letters responding to a certain article, and that's obviously a healthy way [of advancing debate] (UK interviewee J, 2000).

It is generally true that scientific arguments are necessary to encourage healthy scientific debate. There are, moreover, specific reasons to question whether it is in protagonists' interests to sideline sceptical arguments. This relates back to the case

made earlier about the links between debate, funding and professional livelihoods. If contrarian research and publications maintain a degree of uncertainty within climate science, it may be beneficial for all sides in the debate in strengthening the case for further funding as a means of resolving important outstanding differences. If anything, therefore, climate protagonists may have a vested interest in seeing that sceptics get their research published in peer reviewed journals.

Nevertheless, some climate contrarians who perceive difficulties in publishing in mainstream journals, are encouraged to seek alternative means to disseminate their knowledge, including the mass media. Indeed, some sceptics may deliberately choose alternatives to the conventional academic means of information dissemination in an effort to reach a different audience. Chapter Five also noted that some scientists, such as those associated with the George C Marshall Institute, use their knowledge and research regarding climate science as a means to push a particular political perspective. Realising the problems associated with academic peer review publication and the probability that anything they write in this vein is likely to fall foul of the criteria for academic scrutiny, such scientists may take a strategic decision to promote their research through alternative channels. Moreover, publishing or disseminating knowledge via the mass media, in particular, will probably result in their work reaching a wider audience. This may strengthen support for their views and increase their influence upon policy-makers. As a result, they frequently write for a broad, non-expert audience, aiming also to be accessible to politicians who may struggle to follow the full intricacies of any scientific argument. Although work in this form may not have the credibility or legitimacy associated with refereed publications it is often incorporated into the broader scientific debate through mutual citation by particular scientific practitioners. Leading US contrarians, such as Singer, Michaels, Seitz and Nierenberg all regularly refer to each others' arguments. Furthermore, individuals associated with the George C Marshall Institute and the US Science and Environmental Policy Project (SEPP) regularly publish jointly authoured material as a means of strengthening their authority.

This recognition of the use of alternative avenues to disseminate climate knowledge prompts the following investigation of the relationship between UK and US climate scientists and the mass media. This will also return the argument to the theme of funding, by considering the potential ability to affect policy on research funding and the

distribution of resources, that some scientists acquire through maintaining a high media profile..

6.4 Mass Media and Science

6.4.1 The Mass Media: An Introduction

The mass media incorporates the press, radio and TV, especially those channels transmitted terrestrially. This section is principally concerned with UK and US newspapers and television programmes and their reporting of news information. The daily press in both Britain and America is divided into different categories by perceived journalistic weightiness, circulation and political inclinations (Cracknell quoted in Hansen 1994 p.5; see also Chapman *et al*, 1997). However, while the British newspaper industry is dominated by a handful of national papers, the US press is more diverse, reflecting the much greater importance of a regional press focused on the hinterland of the major cities.

In all media, different themes and topics – political, economic, social and environmental – are inevitably thrown into competition with each other in a struggle for coverage (Dunwoody and Ryan, 1983). Even within a single news area there is rivalry between specific stories and individual journalists as each attempts to gain the greatest number of column inches. In this struggle it may not be the intrinsic worth, or importance, of the news item, but the way that it can be sold, which may determine the extent of coverage. Thus stories that are sensationalist; that appear relevant to a broad spectrum of the public; that can be presented as new or exciting; or that are light-hearted may win through, because they appeal to editors concerned to maintain circulation and audience figures (Dunwoody and Griffin, 1994). It is for this reason that journalists, on the one hand, and scientists, on the other, may deliberately sensationalise a story to increase its appeal to the intended audience of a particular news outlet (Hannigan, 1995).

UK and US editors play an important part in determining whether stories about environmental issues such as climate change get media coverage. The decision as to whether to 'run' with any particular story involves consideration of its audience appeal and the potential implications for circulation and, hence, advertising revenue. It is usually in meetings of editorial teams and in exchanges between editors and reporters

that the crucial negotiations concerning the selection of stories and the extent of coverage to be devoted to each take place (Chapman *et al,* 1997; Dunwoody and Ryan 1983). This process of editorial decision-making appears analogous with the role of the academic editor as gate-keeper, discussed above.

The following section focuses on how the mass media portrays climate science. It will initially examine how global warming is reported in the news. Inevitably, climate science, as a slow process of academic exploration of complex issues, sits uneasily within a news agenda driven by instant coverage of events and a need to simplify the presentation of issues (Henderson-Sellers, 1998; Ward, 2002). Attention will then turn to consider the extent to which climate change stories engage with science in a substantial and sophisticated way, or whether reporting is simplistic or sensationalist. This section concludes by analysing the role that climate scientists themselves are perceived to play in placing stories on the news agenda and shaping news content.

6.4.2 Mass Media Reporting of Climate Change

Chapman *et al* (1997, p.47) claim that environmental stories are frequently sidelined 'in the battle for space and time'. As Hendersen-Sellers (1998) notes, time is a key factor in the media and an important point of disjunction with the sphere of scientific research. The news operates within a timeframe measured in terms of hours, or at most days, yet the development of science extends over months and, often, years (Hendersen-Sellers 1998). Reporting is thus biased to favour daily time-frame stories, rather than issues such as climate change that are considered slow burning by journalists and editors. Moreover, global warming cannot easily be presented in a way that makes it a journalistic 'sound bite' because of the sheer complexity of the scientific subject matter (Chapman *et al,* 1997). Journalists themselves often find environmental issues complex and complicated, and, hence, difficult. Such issues require a relatively advanced understanding of science if the subject is to be reliably reported. Indeed, the media has been charged with frequently miscommunicating climate change stories as a result of misrepresentation and misunderstanding (Henderserson-Sellers, 1998).

The first time journalists 'discovered' global warming they were able to 'splash' the story. This was noted by a UK commentator amongst the interviewees participating in the present study. He argued that coverage often had a particular bias:

> It tends to be environmental journalists not the science journalists [who report on climate change], and the environmental journalists tend to form an apocalyptic view of the world...scare stories sell...it's easier to sell a scare story and get front page coverage (UK interviewee S, 2000).

Subsequently, extreme climate events, taken by some to be evidence of global warming, have triggered a brief rash of climate change stories across the media. However, journalists and editors have to consider the issue-attention cycle of the public, which works against extended coverage of any story. The media's appetite for specific and sensational events can sometimes be exploited to obtain coverage for environmental stories. A celebrated instance in relation to climate change was Hansen's public warning of potential catastrophe as a result of global warming, made in 1988 to a US congressional hearing staged at a time of extreme summer heat and drought. In the following days the US mass media carried extensive and high profile coverage of Hansen's statement (Shabecoff, 1988). Not only did this episode and the way it was reported successfully draw attention to the issue of climate change, it also secured it a place on the political agenda (see Chapter Two, section 2.3.4). After two or three stories about the same issue, however, journalists are usually unable to argue for further coverage; old news ceases to be interesting. This works against sustained coverage of environmental stories and may even mean that some issues never find a place on the news agenda, as the environmental journalist Alex Kirby notes:

> there is an awful lot of what I would consider as environmental stories that I don't bother with, not because I don't think they are interesting but because I don't think they are going to get anywhere (quoted in Hannigan, 1995).

Extreme climate events, however, are not the only trigger of media coverage. The release of key scientific reports and studies, such as those produced by the IPCC every five years, as well as significant international conferences or initiatives, for example, the various Conference of the Parties, produce media coverage. Indeed, at the time of writing, global warming is gaining media attention as the Earth Summit in Johannesburg gets underway. Although such events do not raise concerns about sensationalism, as has been suggested above, they do often inspire political controversy as they have direct policy implications which create stimulating features.

The news media, therefore, appears to encourage controversy in the climate debate in its search for interesting and exciting stories. Indeed, climate stories may be presented as

politically, as well as scientifically, controversial. This was noted by a US sceptic amongst the interviewees, who suggested that a television corporation 'had a particular vested interest' in misrepresenting the George C Marshall Institute and the climate scientists associated with it (US interview L, 2000). The interviewee claimed that the corporation took a deliberately provocative stance in the hope of making their programme controversial, interesting and widely watched (US interview L, 2000). But more than this, however, it seems likely that the television corporation was trying to make a political point. But the George C Marshall Institute scientists were also playing their own political game. They appear to have solicited the coverage themselves. This reflected the hope that coverage of their scientific arguments would win support for their political perspectives and thus influence the wider political arena. The attempt, however, appears to have backfired.

Media interest in climate may, at times, raise the profile of the subject. However, this is not necessarily advantageous to climate science, because the subject may be presented in a way that is selective, inaccurate, or insensitive. In the light of this potential for climate change stories to be distorted we might ask why climate scientists become involved in the mass media.

6.4.3 Climate Scientists and Direct Media Involvement

This section analyses the thoughts of UK and US climate scientists, to investigate the roles that they perceive themselves to play in putting stories on the news agenda and shaping the news content. Most importantly, it examines the extent to which climate scientists perceive involvement in the media to be a means of gaining scientific, and ultimately political, influence.

Scientists are sometimes uniquely positioned to place certain issues on the public agenda because society values their expertise and thus has an interest in their research (Hannigan, 1995). Society relies on scientists to identify and explain many of the most difficult environmental problems. This involves, to some degree at least, a public profile for the scientists involved as they participate in a wider dialogue with publics and politicians to shape a policy response. Because of their expertise, scientists are in a unique position to introduce new issues on to this public agenda. Indeed, without their involvement policy makers are more likely to make bad decisions in framing any

response (Liftin 1994). Bell (1973) went so far as to predict an imminent shift to a society where theoretical knowledge was central to policy formation and scientific experts would be the primary advisors to government and business. Some signs of this are evident with respect to climate change, where the IPCC has an important role in informing politicians of advances in climate research. Climate scientists have created a viewpoint which cannot be ignored because global warming could pose a serious threat to society and the environment.

The charge has been made that some environmental stories are effectively censored because 'politicians, bureaucrats, and corporate managers regularly insist that information about environmental risks and crisis be channelled through them' (Tankard *et al,* 1991, p.11). However, most academic scientists are not beholden to politicians or other agents of control and feel free to discuss their work. This partly reflects scientists' perceptions of their own roles; not least the idea, discussed earlier, that the academic world is independent from other societal interests. Indeed, it is invariably the case that academic scientists are freer to voice their concerns than those contracted by business, or government employees, such as Met Office scientists. Individuals in these latter categories are often discouraged from communicating with the media about climate change, seemingly to protect the interests of government agencies and business (UK interviewee G, 2000; UK interviewee E, 2000). Given the controversy surrounding climate science and the potential that climate change has to impose structural limitations on the development of modern societies, it is not surprising that some degree of censorship exists in these cases.

Those scientists who opt to become involved with the media, especially when dealing with controversial and policy relevant science, risk exposing themselves to heightened public scrutiny. The results of this are not always positive for a scientist's work and reputation, especially if the media exposure appears premature and the scientific results untested. This was highlighted by the case of Dr Arpad Pusztai (1998), whose work on the potential health risks of genetically modified organisms (GMOs) attracted considerable media attention (BBC News, 1998). Pusztai's work on GM potatoes and their apparent ill-effects on rats received coverage on UK television before it had been academically 'validated' by the publication of peer reviewed papers. This left Pusztai in a vulnerable position. It was relatively easy for opponents to discredit his work, and his own academic institution sought to distance itself from controversial and 'unproven'

claims (Tudge, 1999). Episodes such as this suggest further reason for caution amongst scientists regarding media involvement. Some scientists may feel inhibited about media coverage, not because of any perceptions of censorship, but because they are wary of the implications for their work of intrusive or inaccurate reporting.

Yet scientific research continues to attract media attention and there are good reasons for scientists to seek coverage for their work. Litfin (1994, p.33) argues that 'scientists care and are committed to specific values ... they believe in the value of their own information'. Assuming this to be the case, some scientists may be driven by a moral duty, rather than any search for individual advantage, to disseminate their findings to the widest possible audience. A UK interviewee supports Litfin's suggestion, asserting that:

> it's the duty of the scientists to inform the public and I think it's a very rewarding thing to do (UK interviewee G, 2000).

Indeed, if the public pay for science, then perhaps scientists should be available to inform the public of their research. Public communication by scientists, however, does extend their accountability beyond the scientific community (Nelkin, 1987). Hendersen-Sellers (1998, p.429) notes that scientists generally believe that they have a duty to communicate their results to the widest possible audience as a means of educating the public, or to 'pay-back public funding'. But controversial science may inspire other motives. Perhaps some climate scientists get involved with the media because they want to advance a specific perspective on the issue, to raise their individual profile as an authority on the subject, and, ultimately, to secure greater funding for their research area.

Elements of such an argument were advanced by individual interviewees. One US interviewee suggested that American scientists who have had their views reported in the popular media have an advantage in the competition for further funding because the attention gives them greater recognition and, consequently, credibility:

> if you are well represented in the literature, in the press as well, if you are known in wider circles, then funding is easier. Most funding agencies would like people who are well known (US interviewee D, 2000).

The respondent went on to explain that he has himself encouraged his research group to seek media exposure (US interviewee D, 2000). The US interviewee described how his research group made sure that their work was presented in the 'newspapers ... or written up in the *New York Times* ... as it was helpful in getting funding, to be able to point out that we have such representation' (US interviewee D, 2000).

Other interviewees observed that universities were often keen for scientists to become involved with the media. They noted that deans and other institutional leaders will sometimes pressure researchers to obtain media exposure (US interviewee B, 2000). Larger private universities in the US, such as Stanford and MIT, have a 'system of getting young scientists recognised by the press' (US interviewee B, 2000). These comments accord with previous claims that a national sample of social and physical scientists showed that,

> engaging in the public dissemination of information ... may be instrumental in obtaining 'external' rewards - such as research funding (Dunwoody and Ryan, 1985, p.26).

Yet, interviewees noted that public exposure can sometimes backfire. One respondent suggested that a US sceptic had experienced funding difficulties as a direct result of his assertiveness in expressing his views publicly (US interviewee B, 2000).

The interviewees also raised issues about the ways in which institutions react to the involvement of the scientists they employ in media discussion of controversial issues. One US interviewee drew a distinction between the stance of different institutions. He claimed that whereas large and prestigious institutions such as Harvard and MIT can afford to accommodate vocal and controversial scientists, other less well-established universities may be more defensive of their reputation (US scientists D, 2000). This implies different experiences of academic freedom. Some of the same reservations were expressed by UK interviewees. While positive coverage is supported by institutions, UK interviewees were unanimous that controversial media publicity was not encouraged by universities and their senior staff. This reflects institutional concerns that the reputation of the university as a whole may be coloured by association with maverick individual scientists. Indeed, Dunwoody and Ryan (1985, p.26) note that academic environments do not encourage individuals to become involved 'in the public dissemination of information'. Hendersen-Sellers (1998) also claims that scientists' careers may suffer

and individuals may experience 'retribution' from colleagues if they go against scientific orthodoxy or speak out too strongly about a controversial issue. Relations within institutions may also be soured by personal rivalries when individuals attain a high public profile through media work. The accusation was sometimes made that the time demands of being a 'media scientist' prevent some individuals from continuing to research and teach within their own institutions, with the implication that this undermined their scientific credibility (UK interviewee F, 2000).

Although, there are evidently a number of vocal climate scientists who argue the protagonist case – such as Schneider, Houghton and Wigley, it appears that, given the proportion of contrarians to protagonists, the former are more frequently in the public eye. This is perhaps because they place greater priority on alternatives to the conventional academic means of disseminating their arguments. But it is also the case that they benefit from the need that the media often has to present both sides in any argument. In contrast with the protagonists, all the contrarian interviewees had experience of media involvement. They did not, however, overtly state that they chose public communication as a result of any difficulties with publication in peer-reviewed journals. An alternative motivation was suggested by a US social commentator who argued that sceptics' behaviour reflected their 'concern that people are being mislead' by climate protagonists (US interviewee O, 2000). Such thinking was also echoed in a rather less idealistic list of motives set out by a UK interviewee, who claimed that sceptic scientists have a high media profile because 'they probably like publicity, like getting some money, they may believe in it as well' (UK interviewee K, 2000). In addition, some contrarians may identify media publicity as the best means to gain influence over the policy process for their own scientific and political perspective.

Chapter Three suggested that particularly vocal scientists may be prime targets for 'purchase' by businesses with a vested interest in questioning climate change, emphasising uncertainty and postponing precautionary action. Such a strategy is potentially effective as science is widely perceived to be a privileged good within modern society, and scientists generally command a respectful audience. In turn, individual scientists benefit from a new funding source, whether to support further research, or to enhance their personal income (see Chapter Five, section 5.4). It may follow that some scientists deliberately court media coverage to attract this form of external sponsorship. For example, scientists associated with the George C Marshall

Institute, who do not produce academically reviewed publications, use media coverage not only for the immediate dissemination of their views, but to attract continued financial and political sponsorship. As Nelking (1987, p.18) argues, such scientists are overtly engaged in political campaigning to 'attract support from legislators, corporate leaders and foundation executives'. Interviewees endorsed this argument, noting that some scientists are publicly vocal because media exposure attracts political attention to their perspectives (UK interviewee K, 2000). As another UK interviewee put it, climate scientists' involvement with the 'non peer-reviewed press is a political question' (UK interviewee S, 2000).

The media has also been used by groups and scientists advancing a sceptical stance on climate change to accuse IPCC protagonists of deliberately misrepresenting scientific facts (Paterson, 1996a). As noted in Chapter Five, in mid 1996 the motives of the lead authors of the IPCC WGI report – Houghton, Wigley and Santer – were publicly questioned via the media. Through the *New York Post* and the *Washington Times,* the director of George C Marshall Institute and President Emeritus of Rockefeller University, Dr Frederick Seitz, amongst others, claimed that the IPCC report had been 'constructed, reviewed and finally published' to invoke political action against greenhouse gas emissions (Hendersen-Sellers, 1998, p.436). He accused the authors of the IPCC of 'exaggerating risk...solely – we suspect – to satisfy an ideological objective of aggressively constraining the use of energy' (Seitz quoted in Gelbspan, 1998, p.53). He also stated that he had 'never seen a more disturbing corruption of the peer review process' (Seitz quoted in Melloan, 2001). The lead authors conceded that they had 're-worded' certain section of the report's text, but argued that this was justified in the interests of clarifying the argument. The authority of this particular report, and perhaps, in some quarters at least, of the IPCC itself, was, nevertheless, weakened. Sceptic climate scientists also gained support for their views from specific papers. In the US, the *Wall Street Journal* is particularly interested in conveying and gaining support for the contrarian stance, which accords with the papers' pro-business, pro-Republican perspective (for example, Singer 1997). This was noted by a UK interviewee:

> The *Wall Street Journal* doesn't present a fair picture of climate change science at all. Maybe that's because it thinks its readers want to hear the sceptical views, so they have articles which come from some institute in Oregon .... [The *Wall Street*

> *Journal*] certainly go over board in trying to use them to show a particular end (UK interviewee E, 2000).

The respondent explained that the paper expresses this viewpoint to support the case that anthropogenic climate change should not inspire either concern, or political action (UK interviewee E, 2000). Similarly, the *Washington Post* promotes a sceptical viewpoint about global warming (see for instance, Warrick 1997).

Arguments about the links between media exposure and funding are, however, by no means simple. Two US interviewees (US interviewee O, 2000; US interviewee P, 2000) made the case that scientists who adopt a high profile on climate change sometimes have a primary interest in other research areas. As a result media exposure – whether negative or positive – has relatively little impact on their ability to access grants for projects for this other research. A case in point may be Stephen Schneider, a US protagonist based at Stanford, one of the wealthiest universities in the world. Schneider's work on climate and climate physics have made him well known, but he holds a full professorship in the Department of Biology, giving him the opportunity to work in a number of different fields (US interviewee O, 2000). Schneider thus enjoys academic security and regular public communications regarding climate change cannot threaten his position or career. Equally, Richard Lindzen, one of the most vocal US contrarians, holds a permanent tenured position and professorship at MIT, a high-status institution. Lindzen has also reached to pinnacle of his profession and is seen to have nothing to lose by taking a public stand (US interviewee D, 2000). Although vocal contrarians are less numerous in the UK, a similar argument can be made about one of the most prominent, Professor Phillip Stott of the University of London (Amos, 2001). Stott holds an emeritus chair in a field, biogeography, that is related only indirectly to the study of climate change. He thus has few constraints upon his freedom to speak out. Another UK sceptic, Dr Piers Corbyn, is founder and managing director of the forecasting organisation Weather Action, and also lectures at South Bank University in London on computing and mathematics (Guldberg, 2000; Revis, 1997). Again it is evident that his professional posts are not necessarily related exclusively to climate science. All these scientists are thus in a strong position to advocate controversial views publicly (UK interviewee S, 2000).

Such high-profile scientists are often successful in the media because they understand its mechanisms, they are precise, able to think across disciplines and translate scientific

language into ordinary English. But they also ignore the uncertainties that are a necessary part of the scientific discourse (Dunwoody and Ryan, 1983, p.647). Indeed, they have 'a natural ability, and learn or cultivate the talents, of effective communication with and through the media' (Hendersen-Sellers, 1998, p.430). The media, therefore, often relies on these scientists for their opinions on global warming. However, the position of media-involved scientist's may be manipulated; if, for example, their prestige is used to legitimate policy objectives in areas beyond their specific expertise (Litfin, 1994). Such strategies may help to explain the presence amongst the most vocal commentators on climate change of scientists whose research is not exclusively related to global warming. Governments and other interests may find it convenient to use vocal sceptics as an excuse to ignore the advice of the IPCC. This is arguably particularly the case in the US under the administration of George W Bush. Disagreement amongst experts – here between vocal climate protagonists and sceptics – can also be used as a reason to delay action.

Interviewees universally recognised the personal financial gains made by media-active scientists. Furthermore, media exposure of global warming resulted in political attention and, thus, funding for climate research (UK interviewee K, 2000). It is generally the case that media communication gains support for research funding (Gascoigne and Metcalfe 1997; Henderson-Sellers, 1998; Dunwoody and Ryan, 1985). Thus, motivation for eminent scientists' media involvement is perhaps twofold – to gain political publicity, which will in turn gain both further research funding for the subject, and to increase the individual's personal funding. Some climate scientists are prepared to become involved in the media because it raises public awareness of the issue. But often the motives are mixed, reflecting both a moral responsibility to communicate scientific knowledge and increase public understanding, and a desire to raise an individual's profile. This was neatly expressed by one UK interviewee:

> Perhaps I like being on television, I don't know! I'm vocal because... I used to believe in the fact that if we speak out this would perhaps attract some good publicity and get people to come towards us. Our motive is that we believe it's right... I probably enjoy being on television at times, but if I only wanted to be on television I could always find something else to do (UK interviewee K, 2000)

It appears, therefore, that media-involved scientists are genuinely concerned about global warming. They may have a mixture of other motives – including access to political influence and research funding – but they are not solely interested in using the

subject as a vehicle for getting on television. Although, of course, if they were, it would be unlikely that they would openly acknowledge such motives.

6.5 Conclusion

The first half of this chapter set out to investigate the experience of climate scientists, considering the possible influence that they obtain within the global warming debate through publishing their research through academic circles. It highlighted that scientists' manoeuvres within the publishing process contradicted the Polanyi (1962) and Mertonian (1973) models of objective science. Some scientists are motivated to publish articles to advance their careers and university profiles, and help secure further research funding. However, some scientists also believed that it was their moral duty to disseminate knowledge to a wider audience. Increasing institutional pressure on scientists to publish and target prestigious journals may lead some scientists to research well-funded subject areas, in the belief that this will generate a number of high impact papers. Recognising the pragmatic manoeuvres of some climate scientists, it is possibleto question the integrity of the peer review process. This is perhaps even more serious when considering the alleged claims of discrimination by some sceptics regarding their experience of publishing their work. They accused protagonists of systematic discrimination, asserting that their papers were marginalised or excluded. Within an extremely competitive environment which is compounded by struggles between particular viewpoints for academic credibility and influence within the policy arena, there is perhaps a motive for some protagonists to attempt to discredit climate sceptics. Protagonists may, therefore, discredit sceptics to strengthen their own credentials. However, it was recognised that scientific debate is crucial for the advancement of science. Thus, some sceptics' assertions are more a reflection of individual grievances. Specifically, the continuing publication of contrarian research serves, in itself, to perpetuate a degree of uncertainty within climate science, thus encouraging further funding to advance understanding of the issue. It is perhaps the case, therefore, that protagonists have an interest in seeing that sceptics get their research published. Indeed, Table 6.1 highlights the successful publication of papers relating to climate change in three leading academic journals by six prominent US contrarians. Although the number of publications produced by sceptics was smaller,

compared to their counterparts, Table 6.1 suggests that contrarians were not completely marginalised.

It is appropriate to remind ourselves of Litfin's (1994, p.29) claim that 'The power of scientists to interpret reality has itself become a productive source of political power'. Scientist's academic influence is gained primarily through the validation and publication of their knowledge in peer-reviewed outlets. In this context scientists themselves make most of the key decisions about what is published and withheld. Academic referees and editors exert a particular influence upon the publication of papers by specific researchers and the degree of exposure available to the different arguments of sceptics and protagonists. However, the readership of academic papers is usually small and restricted to the scientific community itself. Scientists may, therefore, pursue other avenues to attract attention to their arguments, including coverage in the mass media. Such reporting reaches a much wider public and political audience than the vast majority of academic papers. Media scientists may, therefore, gain a greater influence upon public and policy debate.

The second half of this chapter, therefore, considered the mass media as an alternative or complementary outlet to peer reviewed academic publications. It examined the motives of scientists who seek a media platform. As a subtext it considered the triggers for media reports on global warming. It was noticed that the media encourages controversy by presenting stories which are both politically and scientifically contentious in the search for interesting and exciting stories.

Significant events, such as international climate conferences, or the release of reports or key research, also gain coverage. Yet, global warming stories were often inaccurate and selective (Hendersen-Sellers, 1998). With such problems associated with the presentation of scientific information the reasons for climate scientists involvement with the media were analysed. On the one hand, climate scientists appeared to engage in public communication as a means to gain scientific, and ultimately political, influence, knowing that disseminating or publishing their work via the mass media probably results in their work reaching a wider audience. This may increase support for their views and their influence upon policy-makers. On the other hand, climate scientists claimed that some individuals were active in the media because they were more likely to raise their individual profile and have an advantage in the competition for further

funding. It was also noted that public dissemination of knowledge perhaps helped to secure greater funding for the climate change field. Some climate scientists, however, may simply engage in the media because they believe it is their moral duty to disseminate their findings as widely as possible.

It was also recognised that climate sceptics are more frequently in the public eye. This is probably because they seek alternative routes to publishing their knowledge. They also benefit from the media trying to represent a balanced view of the issue considering the majority of climate scientists are protagonists. Thus, climate sceptics are perhaps individually more influential within the climate debate because of the extent of their media coverage, by comparison with the mass of protagonist scientists.

CHAPTER SEVEN

Conclusion

a society which measures man's worth in terms of volume of publications accumulated is no less sick than one which measures his worth in terms of dollars amassed. The academic community has no right to cast stones – it has taken on the values of the society which spawned it, substituting stacks of paper for stacks of money... (Stea, 1969, p.1).

7.1 Recapitulation: Theoretical Foundations

The science of anthropogenic climate change is complex, contested and uncertain, and continues to be debated amongst scientists, politicians, commercial interests and the wider public. Within science itself, differing opinions can usefully – if rather too simply – be represented as a division between contrarians, or sceptics, who question the scale, and even the reality of anthropogenic climate change, and protagonists, who argue that such climate change is not only real, but a serious threat to the continuing development of established socio-economic systems.

It is this potential impact upon both environmental and human systems that renders climate change more than a matter of scientific debate. The adverse effects of climate change could destroy habitats and property, undermine livelihoods and exacerbate social inequality on a national and a global scale. Hence, some concerned observers argue, the need for urgent action to reduce existing emissions of greenhouse gases. Key means for securing such reductions include significant advances in energy conservation and efficiency, and a switch from dependency on fossil fuels to much greater use of energy derived from renewable and low-emission sources. An optimistic reading of this process of change is that it guarantees the continuation of economic and social development in the long term, while also creating specific new commercial opportunities for producers of alternative and sustainable energy. But counter arguments abound; these not only stress the short-term costs of transition and the potential loss of economic growth and social welfare entailed, but also question the necessity for any immediate action at all, in the absence of any absolute proof of human impact upon climate.

This wider debate about the impacts of both climate change per se and the policies proposed to address it inevitably focuses greater attention than would otherwise be the

case upon the work of climate scientists. This expert group is not only our chief source of information about the workings of global climate systems and future climate trends, but potentially also an important influence upon the framing of policy responses to climate change and the urgency with which they are pursued. External scrutiny of the activities of scientists and the circumstances of the production of scientific knowledge is not, however, peculiar to the case of climate scientists. Indeed, the thesis has been able to draw upon a substantial literature which explores the potentially complex relationships between science and scientists, on the one hand, and a broad range of economic, social and political interests, on the other. Often, such work aims to explore the nature of the links which bind science and society together; a mutual dependency which ultimately rests upon society's need for the knowledge generated through scientific research, and the needs of scientists for the injection of continued funding to facilitate this research. Exploration of the process of exchange between scientists and external sponsors, however, throws up further questions about the extent to which the production of scientific knowledge is influenced by the availability of funding. At the very least this may distort the scientific agenda by directing research efforts differentially towards ends that interest specific powerful sponsors. At worst, it is sometimes alleged, the power of money acts to undermine scientific integrity, leading to scientific 'findings' that are not an objective representation of reality, but a reflection of the self-interested world-view of a particular sponsor. Any such distortion of scientific 'truth' is, arguably, not only particularly likely, but also likely to have particularly profound societal impacts, where – as is the case with climate change – research addresses areas of knowledge that are academically contested and bear directly upon commercial and political policy (Jones, 2002).

The specific study of climate change science and its practitioners presented here should, therefore, be viewed in relation to a wider body of research addressing the nature of science as an activity and scientists' relationships with other societal actors. Previous attempts to theorise the relationship between science and society have included those which tend to polar extremes. Accounts such as those advanced by Merton (1973) and Polanyi (1962) present an idealised science that is defined as a separate sphere of activity where the pursuit of knowledge proceeds unencumbered by external influences. At the other end of the spectrum, some reductionist interpretations of Marxist political economy argue that the economic base exerts such an all-embracing influence upon social and intellectual life, that the course of production of scientific knowledge is

entirely determined by its external paymasters (cf Bunge, 1991; Sohn-Rethel, 1975). For reasons detailed in Chapter Three, neither of these perspectives seems a useful theoretical starting point for the present study. The existence of such views of science is, however, a useful counterpoint to the neo-Marxist approach adopted here. We must also remember that the ideal of science as an independent sphere beyond the influence of external interests is still widely cited as a justification for the privileged status often accorded to scientific knowledge. It is thus a view of science that retains an appeal for some of the scientists interviewed for this thesis and, doubtless, also for many of those who sponsor science.

Initial empirical discussion of the recent evolution of climate science in Chapter Two suggests that any theoretically-informed account of scientific activity must take account of its relationships with a wider political, economic and social context. However, it appears that the complexity of these relationships cannot begin to be accurately represented by crudely reductionist models that accord a dominant influence to an undifferentiated economic base. By comparison, engagement with neo-Marxist models of society and of the links between economic interests and other societal forces offers the potential to address the undoubted external influences upon scientific activity in a more sophisticated fashion.

As noted in Chapter Three, the thesis thus starts from the position that the workings of a capitalist economy exert an influence upon the character of the state, and on the conduct of science. Economy, politics and science should not, however, be taken to constitute a simple unity of interest. Indeed, the logic of the different roles allocated to the economic and political spheres is that the latter should preserve at least a degree of autonomy (cf Block, 1987a, 1987b; Miliband, 1977; Poulantzas, 1978). The state can only perform its allotted role of manager, or guardian of the long-term survival of capitalist economic growth, if it has the freedom to pursue policies that work against specific capitalist interests in the short term (Miliband, 1969; Schwarzmantel, 1994). Preservation of the health of the environment is a case in point. Action to combat environmental degradation is unlikely to be adopted voluntarily by business where it runs counter to the short-term pursuit of profit and economic growth. But such action is often necessary to preserve the integrity of environmental systems on which long-term economic development depends. If the state is to promote effective environmental action in such a context it must have the means to overcome business resistance. This requires not only

that the state has the political means to promote effective environmental policy, but also that such policy is legitimated by scientific understanding of environmental processes and problems.

Thinking in this way immediately suggests that there are likely to be several different motives for external sponsorship of research in environmental science. It is not simply the case that business will sponsor research – either directly, or through its influence over state funding systems – that has the greatest potential to advance its short-term aims of economic growth and pursuit of profit. The state may also sponsor research that aims to identify and address environmental threats to the long-term survival of existing economic and political systems. This, in turn, may create new motives for business sponsorship of research in response to this diagnosis of environmental problems. Nor, evidently, should we assume a total unity of interest within the two spheres of business and politics. As just noted, state-directed funding for scientific research may be directed both towards projects with direct commercial applications and those which reveal the necessity of addressing the environmental costs generated by business. At the same time, particular sectors of business may come to regard specific environmental issues in different ways that inspire different interests in scientific research. For energy-intensive heavy industry climate change is potentially a problem to be down-played because the policy response threatens to impose major short-term costs. By contrast, business interests keen to exploit the commercial opportunities of emission-free energy sources may actively seek to promote science that promises to increase demand for their products by maximising the environmental and economic threats associated with climate change. Other business sectors, such as the insurance industry, have their own reasons for seeking clarification of the expected extent of damage and liability caused by climate change (Paterson, 1996b).

Neo-Marxist models thus offer a logic for the existence of a diversity of interests as competing influences upon the scientific agenda. Indeed, the population of actors can be extended beyond the different branches of the state and the various sectors of business to embrace a growing number of non-governmental organisations (NGOs) representing a whole series of social, economic and environmental interests. However, the view of science outlined above also raises questions about the role of scientists themselves and the specific conduct of science that are less well addressed by existing theory, which chiefly focuses on the spheres of politics and the economy. Hence, the empirical focus

of the present thesis and the attempt made to explore the actions and opinions of climate scientists.

If existing neo-Marxist theories of the state help us to outline the different potential motives that may explain external sponsorship of science, they are less forthcoming as a starting point for any attempt to explore the extent to which scientists themselves set the agenda for research and participate as active partners in decision-making about the distribution of funding. Yet, clearly, there are good reasons for thinking that scientists do often play such active roles, rather than being cast as the passive recipients of funding distributed by outside interests. Science is valued by society because of particular insights it offers into the nature of human existence, the character of the physical world which we inhabit and the effects of interaction between human and natural systems. Such knowledge confers influence upon those who produce it. As noted above, the links between science and society rest not only on the financial demands of science, but also on society's need for the 'useful' knowledge which, uniquely – at least in the world-view that constitutes modernism – derives from science.

It follows, as Litfin (1994, p.29), amongst others, has argued that 'The power of scientists to interpret reality has become a productive source of political power'. This is not, of course, to assert that the 'political power' accorded to scientists by virtue of their expertise cannot be over-ridden or outweighed by other forces. Indeed, the existence of contrary scientific opinion on a particular issue may in practice reduce the status of the scientist as expert. Rather than policy being shaped by a definitive scientific opinion, other actors are able to select and promote the science that best serves to legitimate their existing stance. Therefore, as noted in Chapter Three, it may be better to regard expertise as conferring influence – that is 'an episodic effect on decision-making' (Arts, 1998, p.58) – upon scientists, rather than any more enduring ability to direct the determination of policy. But such claims maintain expectations that some scientists, at least, play an active role in shaping state policy in areas such as environmental protection. Moreover, in so doing they are also making decisions that will directly affect the future distribution of research funding in related fields. This raises questions, that can best be addressed empirically, about the extent of scientific influence and the degree to which it is consciously wielded in particular instances. Nor it is clear whether the influence that is deemed to derive from expertise is exerted by the broad mass of scientists, or only by a minority whose particular scientific reputation or political

enterprise enables them to secure positions of authority. We must also consider how any such influence might be evident within the scientific sphere.

Attention to definition of the research and policy agenda as a means of influencing the distribution of research funding must also be complemented by exploration of the dissemination of research results. It may be particularly important to ask in situations, as is true of climate change, where there are competing scientific interpretations of reality how any struggle for status as a single legitimate and correct understanding is played out. Here, denial of funding for alternative perspectives may be reinforced by attempts to block the circulation of the ideas they embody through established scientific channels of publication. Increasingly, however, any denial of access to traditional academic means of information dissemination may be effectively overturned. Use of the general media and the world-wide-web offers alternative voices the means to reach much larger audiences than could ever be envisaged via academic publications.

The recognition that contest, both internal and external to science itself, impacts upon the process of scientific research has potentially profound implications for our understanding of the nature of the knowledge generated as an end product. Idealised visions of science accord legitimacy to the knowledge produced because it is the result of a disinterested search for 'truth'. How then are we to view the outcome of a process of scientific production that seems tainted by the involvement of vested interests? Certainly there are commentaries upon climate science that question the legitimacy and veracity of sections of its output. Often this relates to charges that the process of production of scientific knowledge has been unduly influenced by the economic or political agenda of outside interests involved in funding particular research projects. In some instances, too, scientists themselves are viewed as conscious 'co-conspirators' in a process of distortion, or selective interpretation of scientific evidence. Thus the integrity of some climate sceptics is deemed to be compromised by their receipt of funding from fossil fuel producers and others with a commercial interest in minimising perceptions of any immediate threat from climate change (Beder, 1997, 1999; Gelbspan, 1998; Legett, 1999; Lubbers, 2002; Rowell, 1996). Equally, charges have been laid against some climate protagonists that they knowingly work with environmentalists and interests including the promoters of emission-free energy sources, to produce science that exaggerates the magnitude and consequences of projected climate change (Boehmer-Christiansen, 1994a, 1994b; 1997 and forthcoming; Morris, 1997). It is striking,

however, that where such charges have been advanced they are invariably laid against one specific side in the climate debate by commentators sympathetic to its scientific opponents. The impression sometimes given, therefore, is that any 'misbehaviour' is a particular and unusual departure from an otherwise legitimate scientific process. Such work seems more a continuation of scientific arguments about climate change by other means, than a balanced attempt to understand the nature of climate science.

The argument thus far provides a useful way of thinking about the climate change debate and the conduct of climate science. It also serves to reinforce the case for further empirical investigation; we must therefore turn to review the main findings of the research undertaken here.

7.2 Funding in Practice and its Implications

Given the theoretical importance attached to the financial connections between science and other societal actors it seems appropriate to start by exploring the available information about the scale and sources of funding for climate research outlined in Chapter Five. It should be noted at the outset that fully detailed information about such funding is not readily available. Even published figures for state expenditure on climate research do not allow us to distinguish definitively between funding for climate research per se and research on the implications of climate change, the potential for preventative and ameliorative action and the development of alternative energy systems. The fact that published figures for state funding in both the USA and the UK are broken down by government department or funding agency does, however, allow us to make some informed estimates of the proportion of funding devoted to particular ends. In the UK around two-thirds of climate research funding is distributed through NERC; this is the most likely sponsor of work investing climate change itself and its effects on environmental systems. By comparison, the US government advances much greater funding for climate research, but only a small proportion is distributed through the NSF as a major sponsor of basic climate research. Some of the funding allocated via NASA, the largest single funding agency, will also be devoted to basic climate science. However, what is really striking about the US government figures is the scale of funding provided by government departments whose chief interest is likely to be in applied research in fields such as energy and agriculture. The figures presented in Tables 5.1 and 5.2 show that overall the US government provided just under six times

the amount of funding for climate research provided by its UK counterpart. The US Department of Agriculture, however, advanced 22 times more funding than the UK Ministry of Agriculture.

This distribution of funding in some ways runs counter to expectations. In the UK there is a substantial measure of acceptance of the scientific reality of climate change in official circles. This is reflected in a commitment to attempt to meet the targets for emission reduction stemming from the Kyoto Protocol. Clearly, however, this does not preclude continuing investment in basic research; much more is still to be discovered about the scale, timing and geographical patterning of both climate change and its environmental effects. However, there seems, on the face of it to be a stronger case for continuing investment in basic research in the USA, where arguments about the uncertainty of the existing science have been used in government and other circles to justify the lack of a definite commitment to specific emission reduction targets. More recent figures might, indeed, allow us to identify the investment in research made under the administration of George W Bush in the aftermath of American withdrawal from the Kyoto process. It is a moot point, however, whether any such investment is intended to speed the resolution of scientific uncertainty or to perpetuate it.

For all their limitations the departmental breakdowns of the US and UK government funding totals are useful in apparently confirming that a variety of motives and sectional interests within government account for state support for research in this particular field. The scale of state funding for climate research and its distribution through a series of different ministries and agencies is consistent with the arguments outlined above regarding the state's interest in receiving a range of different sorts of scientific advice. This includes the best available advanced warning about the reality and scale of any potential environmental threat to economic development and, by extension, political stability. Where a threat is deemed to be real and serious, the state also has an interest in applied scientific research that will assist in the identification of strategies intended to reduce the scale of damaging environmental change, or to temper its impacts upon human and environmental systems.

The existence of financial support for climate research from a range of other sources also seems consistent with previous arguments about the range of different motives for funding such research. The scale of funding from non-governmental sources, either in

total or as grants to particular researchers, is much more difficult to discern than was the case with respect to the state. It is clear, however, that money for research on issues related to climate change is being provided by a range of businesses, charities and NGOs. Business sponsorship is almost certainly the largest of these sources, especially in the USA. The motives for business sponsorship of climate research are likely to be different from those of the state – although the activities of the two groups are sometimes intertwined. Business interest in climate science is not necessarily related to the implications of climate change per se, but to the effects of actual or potential state policy implemented in response to climate change.

A sense of the diversity of inter-related interests underlying business sponsorship of climate research is reinforced by acknowledgement of the range of different businesses involved. These include both those that might be expected to have a particular interest in downplaying the anthropogenic contribution to climate change (especially as this relates to modern energy-intensive industrial systems) and those for which climate change brings either specific risks (such as increased costs for the insurance industry) or opportunities (in, for example, the marketing of emission-free energy systems). It should also be noted that these sectional interests within business are not fixed and unchanging. Some major energy companies, for example, were initially chiefly interested in securing scientific evidence that would allow them to continue to question the links drawn between climate change and emissions from the combustion of fossil fuels. Maintaining this position has proved to be not only scientifically difficult, but in some respects commercially unattractive. As a result some energy providers have switched funding away from basic science to invest in the development of alternative energy systems as a basis for future business activity (see for example, Environmental Defense Organisation, 2000; Mastio, 1998; Rowlands, 2000; cf Lubbers, 2002, and Boehmer-Christiansen, 1996).

Other actors in the system of sponsorship that surrounds climate science include NGOs and charities. Some of these are themselves directly connected to business, which provides much of their funding. The George C Marshall Institute, for example, pursues a pro-business and anti-regulation agenda. It is this central interest which not only explains its involvement in debating environmental issues, but also strongly colours its stance on climate change. In contrast, many other NGOs bring very different perspectives to bear upon climate, deriving from primary interests in global

development and the reduction of North-South inequalities, or environmental protection. The sector as a whole, therefore, provides further evidence of the spectrum of different interests involved in contesting climate change. In practice, however, charities and NGOs seem to be of lesser importance as sources of scientific funding than either business or the state. More often, interviewees indicate, the role of these organisations is to promote debate about the implications of climate change and climate change policy. This may, of course, have an indirect impact on the funding process in helping to draw attention to the work and opinions of specific figures. Publicity achieved in this way has consolidated the reputation of certain individuals as leading researchers and commentators, thus increasing their chances of funding from other sources. It is, however, possible that association with a controversial campaigning organisation and particular sectional interests has worked against some researchers' chances of obtaining funding from some more conventional sources.

A small number of leading climate scientists also appear to tap other sources, particularly the media, that represent a further source of commercial funding. Payments – often substantial if the figures quoted in some of the interviews for this thesis are taken at face value – are obtained for television appearances, journalism and private lectures. The fees paid are in many instances a supplement to the personal income of the individual scientists concerned, but some may be devoted to supporting research. Some sections of the media, particularly the press, undoubtedly have a specific agenda to pursue in either highlighting or downplaying the risk of anthropogenic climate change and its likely effects. Often, however, the media aim to present both sides in any argument. This may work to the advantage of the smaller camp of climate sceptics if they obtain equality of coverage with climate protagonists. The result has been to raise the profile of a group of prominent sceptics; although as suggested above any reputation gained as an advocate of a controversial opinion may be a curse rather than a blessing in the search for new research funding.

It is beyond the scope of the present study to compile comprehensive figures for non-state expenditure on climate science, but the evidence of the interviews undertaken here seems consistent with previous arguments made by authors such as Beder (1997, 1999), that the scale of commercial funding in this field is greater in the USA than the UK. The most obvious expressions of such commercial sponsorship have often been provided by the funding of climate sceptics by fossil fuel producers and related interests in sectors

such as the vehicles industry. Indeed, there appears little equivalent logic for commercial sponsorship of basic research by climate protagonists, given the apparent strength of existing scientific evidence about the risks of climate change. Existing climate models are often relatively crude, however, in their indication of the timing and geographical distribution of any change (cf Shackley *et al*, 1998). Further refinement of this predictive capacity is likely to be of interest to sectors such as insurance, but this has not, as yet translated into any sustained commitment to support work in this field (Paterson, 1996b).

Overall, it seems evident that greater funding is available to support research identified with the position of climate protagonists, than is the case for sceptics. Even in the USA corporate sponsorship does not greatly alter the picture. Sceptics amongst the current set of interviewees often reflected this position in their complaints about unequal access to funding, and an equivalent discrimination in the peer review system that determines the publication of research in key journals. It is striking, however, that when interviewed, leading figures in the sceptic camp did not express any sense of *personal* dissatisfaction. They did not present their own research as being handicapped by lack of funding, or opportunities for publishing. In part this seems to reflect an ability to access alternative means of securing research funding and dissemination from the conventional channels of research councils and refereed journals. Arguably rather more than their protagonist counterparts, leading sceptics often derive their current prominence from a willingness and ability to use the media to secure publicity for their ideas. They have also made use of the increasing potential of the internet to disseminate information extensively and rapidly, sometimes using platforms established by pro-business 'think-tanks' such as the George C Marshall Institute. A brief analysis of the content of several leading journals, reported in Chapter Six, shows, however, that sceptical voices are not excluded from prestigious academic journals. This and the important business and political connections that some scientists have forged ensures that while the sceptic camp is not large, it does contain some influential figures. Indeed, in some respects it may serve the interests of climate protagonists that this is so. Many appeared to welcome the opportunity for continuing scientific debate about the future course of global climate. A more calculated argument against the total exclusion of sceptical voices from leading scientific publications and other forums is that it may lead potential funders to conclude that previous uncertainties and disputes have been resolved, thus reducing the need for further research funding. Controversy and debate not only have the potential to advance

knowledge; they also help to maintain the profile of a scientific issue as one that requires continuing research.

Both the published figures for state funding and the more impressionistic evidence of the interviews points to trans-Atlantic differences in the scale and sources of funding available for climate research. This further confirms the limitations of a deterministic understanding of relations between science and society. Indeed, it is not simply the case that a capitalist economic base, taken as a whole, sponsors programmes of research which differ in the specifics of their content in different national circumstances. It is also evident that particular interests, such as fossil fuel producers and motor vehicle manufacturers, have reacted differently to the issue of climate change in the UK and the USA. For example, one of the British climate protagonists interviewed here had received funding from the British arm of a major vehicle manufacturer which had previously been linked to the sceptic position on climate in the USA. Any theoretical account should, therefore, be able to acknowledge and explain such specificity in the goals of scientific, commercial and political actors, and the relationships between them. The neo-Marxist model adopted here clearly outlines a rationale for the adoption of different stances with respect to the environment and environmental policy by specific sectors of government and business. But, as noted in Chapter Three, it does tend to assume that the logic of these positions is essentially universal, and somehow predetermined and unchanging. A determinism based on the assumption of the overwhelming influence of a unitary economic base is replaced by a perspective that is potentially no less deterministic in ascribing particular stances to the series of different economic and political interests which it identifies. Empirical evidence of differences and a degree of fluidity in the position adopted by specific actors and interests suggests that any future research should revisit the initial assumptions made here about the existence and nature of these positions. It may be logical to assume that particular interests will react to environmental hazards in particular ways, but this is dangerous if it leads us to ignore questions about the ways in which actors might construct and reconstruct their own roles and relationships with others in specific circumstances. There are perhaps echoes here of Jessop's extension of neo-Marxist theoretical debate through his focus on the form and function of the state not as some predetermined entity, but as an outcome of past and continuing strategic struggles. Viewed in this way the state is far from being a simple instrument of the ruling class; instead it is dynamic,

reflecting the balance of power within society at any point in time, and is thus an outcome of an ongoing hegemonic struggle (Jessop, 1984, 1990).

Arguably, the state is not bound to fulfil a role as environmental manager, perhaps especially in a context in which many key decisions are taken by individual office holders whose horizons are determined as much by the short-term prospects for their re-election as they are by concerns about the long-term welfare of their citizens. Several interviewees – not exclusively climate sceptics – even asserted the immediate value of concerns about climate change to governments as a means of raising revenue by apparently justifying energy and pollution taxes. Equally, business will not necessarily act in ways that reflect its existing set of commercial priorities, perhaps because it sees an opportunity for greater future profit through promoting change in public and policy stances on environmental issues. This is apparent in the way that leading energy companies are moving beyond a base in the production of fossil fuels to secure a stake in renewable energy markets. We might also recall the changing stance of DuPont regarding the practicality of developing commercial alternatives to CFCs; a change widely seen as important in influencing political decision-making about regulating the production of ozone-depleting substances (Purvis *et al*, 2000).

It seems important, therefore, to learn more about such decision-making in practice; about the extent to which specific actors are seen and see themselves as having the power to respond in different and changing ways to particular environmental issues; about the range of contingent factors which influences any such process; about the specifics of relations between different interest groups and the ways in which they influence each other's actions; about the understanding that particular interest groups display about complex environmental issues and the degree to which their responses reflect imperfect knowledge. Ultimately, this points to the need to pay greater attention to the motives and decision-making of politicians, civil servants and business leaders to complement the focus on scientists evident in much research to date, including the present thesis.

7.3 Scientific Voices and Self-Perceptions

This is not, of course, to discount the importance of the evidence provided by scientists themselves regarding their relationship with the sponsors of their research and the use made of scientific knowledge by society at large. The interviews conducted for the present study are interesting in the range of attitudes revealed towards the funding and dissemination of research. At one end of this range were many of the comments made by interviewees from the UK Met Office, which appeared to reflect a particular sense of demarcation between their own role as scientists and the political process of policy making. This presentation of science and society as essentially separate realms – very much in the manner of theorists such as Merton – perhaps reflected the specifics of their institutional context. As government scientists their position was in many respects more akin to the civil service than that of independent research scientists working in universities and other related institutions. Subsequent events have, however, highlighted some of the potential tensions inherent in the relationship between government scientists and their political masters. Public statements by Sir David King, the UK's Chief Scientific Advisor that climate change represented a greater threat to the future stability of world systems than did international terrorism are reported to have provoked a hostile political response. Further accusations followed that Downing Street was attempting to 'muzzle' Sir David to prevent him repeating his argument (Connor and Grice, 2004). It should, of course, be noted that these specific comments do more than highlight the neglect of scientific evidence about the threat of climate change; they might also be taken to imply a criticism of government policy in other fields.

In the main, the scientists involved do not emerge from the present set of interviews as passive or naïve figures. They are aware of the interests that potentially motivate specific sponsors in funding research – interviewee K, for example, referred to the impossibility of undertaking 'neutral research' – and lead to their employing the results to serve particular commercial and political ends. The reality of the position that the basic parameters of their work are set by external expectations that the provision of funding will create a return in the form of useful knowledge also prompted interesting reactions amongst interviewees. Many acknowledged that a lack of funding imposed some limitations on their freedom to set their own research agenda; as interviewee K continued 'There's all sorts of research I would like to do … [but] no one's going to pay me for that'. The existence of funding constraints was not, however, presented as

entailing the total loss of autonomy. Certainly, it did not preclude efforts to secure support for specific projects driven in part, at least, by a personal and professional agenda of scientific curiosity.

This pursuit of personal scientific interests operates at a number of different levels. Interviewees noted the use of relatively simple presentational strategies when applying for research funding. To maximise their chances of success they placed greatest stress in the initial application on those aspects of the proposed work thought most likely to appeal to the sponsor involved. But underlying this statement of intent there were often other issues and sources of motivation that were just as important to the individual researcher. Indeed, interviewees claimed to be aware of specific instances where individual researchers have effectively misrepresented the aims of own work to secure funding. It is difficult to substantiate what is largely anecdotal evidence, but the picture painted of scientists as actively adopting tactical ploys to obtain funding seems consistent with the general tone of the interviews. Such claims also raise interesting questions about the extent to which referees reviewing funding applications, usually scientists themselves, are aware of the element of gamesmanship and act in ways that either perpetuate or frustrate it.

Some individuals are, however, clearly able to go beyond any limited strategy of 'subverting' the intent of funding agencies. This is the context within which the notion of influence (cf Arts, 1998; Litfin, 1994) emerges most strongly from the empirical evidence of the interviews. Individual researchers and members of research teams with a strong personal record of scientific work and publication are undoubtedly in a position not only to secure further funding for their own activities, but also to influence the distribution of funding to their peers. In part this reflects the role that their research plays in shaping scientific understanding and by extension their influence over any related areas of political policy. These, in turn, are amongst the determinants of decision-making about the scale and allocation of future research funding, particularly by research councils, government departments and other state-related agencies. Work that establishes itself as timely and important is disproportionately likely to receive further support. The wider influence that a small number of individual researchers wield on the allocation of funding to the work of others also reflects their role as referees of both research proposals and journal papers (see Chapter Six). In this way certain

individuals act as gatekeepers, shaping both the dissemination of ideas and information and the ways in which the scientific community responds to particular arguments.

The account presented here is thus broadly consistent with the case made by Hart and Victor (1993) that a minority of elite scientists exert greater influence over the research agenda and relations between science and policy than do the broad mass of their colleagues. It is important, however, to acknowledge the qualification to this position made by Paterson (1996a); the influence of individuals is reinforced when they are seen to be making a case that reflects the opinions and interests of a wider constituency within science. Maverick individuals, however senior and forceful, may be sidelined if they are seen only to be speaking for themselves. Moreover, debates over the specific issue of funding for climate science confirm that it is more accurate to attribute influence, as distinct from power (Arts, 1998), to even the most prominent and well-connected scientists. The recent history of state funding for climate research in the USA, in particular, makes clear that significant changes in the scale and allocation of funding do not so much derive from new scientific understanding or expert scientific advice to government, as from change in the party of government and the links fashioned with leading commercial interests.

The case of climate change should, however, also cause us to reflect on the implications of the availability of funding from different sources for different types of research, even within a single field. Potentially, at least, this provides scientists with choices about the conduct of their own research. Although a particular prestige was widely attributed by interviewees to funding from some specific agencies – particularly the research councils in the British context, a status reinforced by the RAE process – they were also aware of the potential availability of funding from the range of other sources discussed above. Interviewees were not asked to disclose specific details of the research funding awarded to them, but discussions for the present study confirm that the majority had secured support from a series of different sponsors. In many individual instances these sponsors included research councils, government departments and various commercial interests. This willingness and ability to tap into a range of different sources of funding implies a further source of flexibility for scientists in setting their own research agenda. This flexibility, which ultimately derives from the value placed on scientific knowledge by a range of different societal actors, rather than the expert status of specific individuals, is thus, in principle at least, available to all, whatever their position on climate change.

It remains true that a need for funding can lead some researchers to 'revise' their scientific understanding in line with the position of potential sponsors. But where sponsorship is available from a range of different sources it may be that compromises on this scale are unnecessary, as researchers are able to seek support from sources whose position on climate change matches their own. Moreover, as suggested above, by participating in research and exchanges between researchers that appear to reaffirm the limitations of current understanding of climate change all researchers help to reinforce the case for further funding. Paradoxically, as previously noted, the continuing lack of agreement between sceptics and the protagonists is beneficial to both camps in justifying continuing investment in research. This should not, however, be taken to imply conscious collaboration between the two camps to secure this end. Any such strategy might also incur the ultimate risk that continuing disagreement only serves to call into question the broader credibility of climate science.

Predictably, there was little to contradict the widespread assumption that efforts to secure research funding are a necessary part of the scientist's role – although the sense of being in open competition for funding was less marked in the case of government scientists employed through the Met Office. This need to secure external sponsorship was not, however, perceived necessarily to involve compromising the objectivity with which research was conducted or its results reported. Nor did interviewees raise concerns that funders commonly imposed any injunction upon the external discussion and publication of research findings. Yet interviewees' characterisation of their own stance and actions as legitimate did not prevent some from laying charges of opportunism, bias and distortion of scientific evidence against colleagues. Indeed, this is not surprising given disputes over the alleged distortion of scientific evidence in key documents produced by the IPCC (particularly the Working Group I report) and the presentation advanced in previous studies of climate science as beholden to various vested interests.

Hitherto, many of the claims made about the influence of vested interests on research have been made in a way that itself presents a rather one-sided image of the conduct of climate science. Particular commentators have tended to concentrate on the allegedly distorting effects of commercial sponsorship on either the protagonist or the sceptic case. This tends to create the impression that any loss of scientific integrity reflects the

particular failings of a specific section of the community of climate scientists. Individual interviewees often presented their claims in a very similar manner, invariably pointing the finger at individuals whose stance on climate change was different from their own. But the inclusion of both protagonists and sceptics amongst the present sample of interviewees shows that such charges were made in both directions. Questions were raised about the legitimacy of the financial support given to the sceptic cause by energy companies and other related commercial interests. At the same time, climate sceptics were equally ready to charge protagonists – sometimes including named individuals – with accumulating substantial earnings, both in terms of personal and research income 'for being politically correct' on climate change (Interviewee N). Interviewee L was particularly blunt in asserting that some scientists place potential financial rewards above their own ultimate convictions by taking a calculated decision to 'support the side that has the most money'. In the light of previous studies where the focus has often been upon the implications of various forms of commercial sponsorship, it is interesting to note that climate sceptics sometimes attributed a distorting influence to state sponsorship of research. More state funding was assumed to be available, especially in Britain, for work broadly in line with the protagonist stance on climate change. As a result, it was alleged, a desire and need to secure such funding had caused some researchers to abandon their previous scepticism about anthropogenic climate change.

Questions raised about the integrity of other scientists were not, however, supported by any specific evidence of malpractice. Instead, interviewees implied that receipt of funding from particular sources led in some, generally unspecified, way to bad science. In some instances it is difficult to avoid the conclusion that an absence of detail reflected a real absence of substance to any charges. Rather, that adverse comments reflected a degree of personal animosity between individuals (cf Breyman, 1993) – something that is not accounted for in theoretical treatments of scientific practice – or an intent to undermine the broader stance on climate change that was being discussed. To test such suspicions and also to subject claims of bad science to more critical scrutiny would, however, be difficult. This is an instance where a methodology based on interviews has limitations. Even with the promise of anonymity interviewees are likely to be unwilling to lay specific charges against their colleagues – although, as noted, some were ready to pass comment in general terms against named individuals! Any such charges would not, of course, constitute proof of malpractice; at best they might

serve as a starting point for more specific investigations. These, in turn, would present any researcher with a formidable challenge both in practical terms – given the likely need to secure further information from powerful and uncooperative sources – and in proving that the collection or interpretation of scientific evidence had been improperly influenced by the demands of external paymasters. The chances of a successful outcome to such research would be increased if accounts of the conduct of specific researchers and of the execution of particular research contracts could be secured from a series of different witnesses. Ideally, this would involve extending the research to include participants other than research scientists. Greater knowledge of the public and private case made by particular sponsors for their support of climate research, and the use made by such sponsors of the research findings would add an important dimension to study of the politics of climate science. Such an approach, however, raises very real problems about access to confidential and sensitive information.

7.4 A Revised Agenda for Research

Neo-Marxist theory, as outlined in Chapter Three, has proved useful in helping to formulate important questions about the conduct of climate science and relationships between scientists and other actors involved in the funding of science. Theoretical expectations concerning the range of potential sponsors of research and their likely motives appear to have been more than borne out. Indeed, the interviews conducted with scientists and the other evidence presented here suggest a diversity of motives for the sponsorship of science and a potential for change over time in the stance of individual sponsors that are not readily accommodated by the initial theoretical structure. Equally, the reported behaviour of scientists themselves suggests that a range of pragmatic strategies exist which allow individuals to retain at least some degree of autonomy. Such strategies are not always implemented at the grand level of agenda setting by influential scientists (cf Lukes, 1974). This points to the need for further study to address the complexity of the circumstances in which climate science is undertaken.

Some of what this further study might entail has been anticipated above. As already noted, interviews with scientists should be set against further investigation of the attitudes and motives of other actors. Just as this thesis has included attention to differences in the stance of scientists, so any further study must engage with the specific

attitudes and motives of individual sponsors of scientific research. We need to know more about how and why these motives differ; this will involve attention to the stance of actors in particular national contexts, the potential for changes over time in the motives and attitudes of sponsors, and an exploration of the potential diversity of opinion at any one time within large institutional sponsors. The influence that potential sponsors exert upon each other, either directly through research funding, or in responding to related policy initiatives must also be taken into account. If we accept that research funding is provided to generate useful knowledge for an external sponsor we also need to know more about how this affects decision-making in practice about its allocation. We need to consider the extent to which the usefulness of knowledge is defined by more than its seeming power to legitimate the existing stance of sponsors.

Perceptions of the authority with which particular scientists speak on specific topics may also influence the allocation of funding. We have largely assumed here that such authority derives from publication of research through established academic channels. It may be, however, that new electronic media for the dissemination of ideas and information are changing the ways in which scientific authority is constructed and perceived. The potential for change in this respect – not least because it seemingly removes the influence of the traditional gatekeepers controlling information dissemination – is worthy of more detailed scrutiny. Ideally, too, we should consider further the extent to which scientific status – and by extension the influence that derives from expertise – is a product of more intangible systems of networking within organisations such as the IPCC and between individual scientists, the media and policy-makers.

Given the sheer weight of existing research on climate change we need to consider the extent to which external interests remain interested in sponsoring further scientific study. As an alternative, business and campaigning groups might consider their money better spent on political lobbying to influence the ways in which existing scientific results are interpreted by policy makers at a national and international level.

It would also be valuable to test the impression gained here of the episodic influence of scientists upon the process of developing climate policy against the perceptions of other actors. This might enable us to be more precise about why and how scientific expertise translates into influence in some instances, yet is sidelined elsewhere. Further

investigation of such issues in the context of climate change could usefully be set alongside studies of other instances of politicised science, such as recent debates over the risks to human health from sources as different as BSE, mobile phones and the use of genetic engineering as a means of enhancing agricultural productivity (Bartlett, 1998; Burgess, 2004; Jasanoff, 1998; cf Wolpert, 2002). Indeed, an element of comparative study is vital if we are to build upon a greater understanding of the specifics of particular cases to refine our theoretical understanding of the roles played by particular actors in debating the implications of scientific research and the resultant relationships between science and its sponsors. Comparison of particular cases might, for example, lead to wider conclusions about the circumstances in which scientific expertise is most likely to be accorded a role in the policy process. For example, does it matter whether an issue is perceived by publics and politicians as a slowly developing threat which can potentially be debated at length, or a sudden emergency requiring an immediate policy response? Urgency may invest scientific expertise with an apparent policy relevance that eludes it in relation to 'slower-burning' issues, even when it might be argued that the advance warning given by scientists contains the key to effective and relatively painless remedial action. Similarly, does it matter whether any danger is seen to have a direct impact on human health, which is perhaps more likely to motivate publics and politicians to seek scientific advice, as opposed to rather less well-defined implications for environmental systems, when the temptation may be to ignore 'bad news'? Other factors which might affect how publics, politicians and other interest groups respond to scientific expertise include the scale of any threat and the implications for the construction of a response. Does it matter whether the latter is viewed as being national or international in scale; or whether any economic costs are likely to extend across an economy as a whole, or be borne by particular sectors? Such questions also point in the direction of greater engagement with the literature on public perceptions of science and the potential for active public participation in the creation of forms of 'citizen science' (see, for example, Irwin, 1995, 1996; Irwin and Wynne, 1996; cf Wynne, 1992, 1995).

Many of the questions noted above raise potentially sensitive issue about the behaviour of commercial and political decision-makers and the extent to which they prioritise narrow sectional interests over considerations of the common good. It is often difficult to tackle such questions directly, both because of the ambiguity of the definition of concepts such as 'the common good' and the likely reluctance of actors to discuss behaviour on their own part that might be viewed as illegitimate. This confirms the need

for further investigation which is structured in a rather different way from the present thesis. This might involve highlighting a series of particular projects in climate science for more detailed investigation. The aim here would be to focus on the different interpretations of the relationships between scientists, research sponsors, policy-makers and other consumers of the research, offered by the full range of actors involved.

A careful choice of projects for investigation would also allow more explicit attention than has been possible here to be paid to change over time in the stance of particular actors, both regarding climate change and the rationale for sponsorship of climate science. The trans-Atlantic contrasts suggested here could also be further investigated, and perhaps extended by investigation of projects involving scientists from other national contexts in both the developed and developing world, or cast as international initiatives under the auspices of the IPCC. This focus on specific instances might also allow more precise comparisons to be made between the observed behaviour of particular actors – whether measured in terms of the provision of funding for particular researchers and research projects, or the scientific opinion reported in resultant publications – and the interpretations of this behaviour obtained through interviews both with the parties involved and other commentators. This ability to establish the degree of consistency with which actions and opinions are presented in different contexts provides an important confirmation of the reliance to be placed on particular strands of evidence.

7.5 Understanding the Nature of Science

If recognition of the value of further investigation of the actions and motives of both scientists and their potential sponsors is one outcome of the present thesis, the work also points to the need for a mature understanding of the nature of science. Research such as the case study offered here cannot realistically aim to change the way in which science is conducted. Rather, it is important that publics and policy makers gain a clear understanding of the nature of scientific knowledge; that it should be regarded not as a indisputable truth, but as a contestable and provisional interpretation of the available evidence. Scientific debate is thus normal and healthy, a perpetual facet of scientific endeavour, rather than being confined to exceptional moments of paradigm shift (see, for example, Shackley and Wynne, 1996, 1997).

Equally, it is impossible in practice for scientific research to be entirely driven by the personal curiosity of individual investigators. Nor is it necessarily desirable for this to be so. The history of science, of course, proves the value of individuals being allowed to pursue apparently inconsequential or ill-conceived research that ultimately delivers profound new insights. It is important that such freedoms are maintained (Lovelock, 1988). But given that the availability of funding for research is always limited it seems reasonable to allocate the bulk of investment in ways that seem most likely to generate useful knowledge. We also have to accept that individual sponsors will have their own definition of what is 'useful' and that the interests of individual sponsors may be at odds with each other and the wider interests of society. Such external sponsorship does not necessarily produce 'bad' science in the sense of deliberate malpractice or misrepresentation of results – although it is evident that such cases do exist (cf Evans and Packham, 2003; Monbiot 2003; Pritchard, 1996). But it does reinforce the message that scientific knowledge is not an undisputed truth, somehow revealed through human actions; rather it is a provisional interpretation that is a product of a particular relationship between scientists, their sponsors and other social actors.

Knowledge of the context in which science is produced is thus important to its interpretation. As Saunders and Ho (2001, p.4) assert, 'a public with critical understanding of science is necessary, both for making democratic decisions on science and science-related policies and in ensuring that science is accountable to society'. Any such critical understanding demands more than a general impression that all scientific research is somehow untrustworthy because it is beholden to vested interests (cf Monbiot, 2002; Tudge, 1999, 2002). Indeed, understanding at this low level may simply cause a damaging loss of public confidence in the value of science and scientists – especially in an era when faith in science is under threat from other quarters (see, for example, Beck, 1998). This is especially counterproductive if it means that, as a society, we fail to recognise that for all its practical flaws science remains our best guide to the workings of natural environmental systems and their interaction with humanity.

As an ideal, therefore, public understanding of science requires a specific and sophisticated approach based on knowledge of the circumstances in which individual exercises in research are conducted. It also requires a greater sense of what science can tell us about the workings of human and environmental systems, and what is beyond the scope of scientific investigation. In the case of climate change, science can clarify our

understanding of the causes and scale of warming, and offer projections of the environmental effects of different future policies regarding energy use. But science cannot tell us whether or not we should adopt particular policy options, for such decision-making necessarily also involves economic and social choices. Any indecision in the face of such choices often reflects not so much a failure of science, but a failure of political will when considering measures likely to be unpopular in the short term.

We should not underestimate the extent to which publics already possess the awareness of the nature of science and the circumstances of its production identified as important above. Previous studies have shown a public willingness to engage critically with science and associated policy debates. This seems particularly to be the case if it is widely perceived that scientific expertise and advice has immediate implications for public health and safety – in instances such as BSE in cattle, or the combined MMR vaccination for children (Irwin, 1995). Yet the consolidation and extension of such understanding and the promotion of a sustained and widespread interest in scientific practice remains a daunting task. Moreover, in a case such as climate change where any public sense of the associated risks to human welfare and economic development is often more diffuse, it may be more difficult to inspire public scrutiny and 'ownership' of the underlying science.

In other contexts academic actors have adopted specific procedures to clarify the context in which specific research projects have been undertaken. These include a requirement to make an overt declaration of any relevant relationships – potentially extending beyond funding – between scientists and sponsors when work is published (cf Evans and Peckham, 2003). This provides a means, should it prove necessary, to clarify the status of individual research. Approached in this fashion greater critical understanding of science need not undermine public confidence in the legitimacy of most scientific practice. Attempts to move in this direction are evident in the policy adopted by several leading medical journals as a response to particular questions raised about the impact of sponsorship by pharmaceutical companies on research in this field. Such journals require authors to declare any relevant business interests, and undertake to publish the results of sponsored drug trials only when they can be assured that the scientists rather than the commercial interests involved have ultimate control of the way that the data are reported (The Times, 2001). A more extreme response from the *New England Journal of Medicine*, which attempted to refuse submissions from authors

receiving more than a given amount of funding from commercial sponsors, is also interesting – not least because the policy quickly proved unworkable due to the reduced number of submissions (Newman, 2002).

The New England case seems to confirm that declaration, rather than exclusion, of sponsorship, is a more practical response to questions about the status of scientific research. There are, moreover, obvious dangers in the extension of any policy of non-reporting of commercially sponsored research in the wider media. Indeed, the mass media perform quite a different task from most academic journals. The latter serve to reinforce the status of research – publication in a refereed journal is widely taken to represent a guarantee of quality in research (Zimen, 1968). Withholding publication is therefore a potentially effective sanction (Goodstein, 1995). The mass media, however, offer a means to inform the population at large about unfolding scientific knowledge and any implications it may have for future human welfare and development. To withhold reporting in these circumstances implies a deliberate attempt to hamper public understanding. Given that it is through the media that most people gain their knowledge of science and its wider implications, this reinforces the importance of the engagement between these two spheres. Good science reporting must not only present an accurate account of unfolding developments in scientific knowledge, but also of the circumstances of its creation. As in the context of academic publishing noted above, one important dimension of this should be clearer statements in media reporting of research sponsorship and any other relevant business interests that link researchers with political and commercial interest groups. Such information should help others – whether publics, policy-makers, or other vested interests – to make an accurate judgement of the credibility that can be attached to expressions of scientific understanding and opinion. Ultimately, however, in a case such as climate change it reinforces the importance of political decision-making with respect to the policy implications of science. As noted above, science can offer informed perspectives on likely climate futures and the potential implications for human and environmental systems. But it is society as a whole that decides – not necessarily in any co-ordinated way – how we will react to any such expert advice.

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APPENDIX A

Social Science Interview Proceedings

Interview proceedings

1. My research concerns the context in which global warming scientists carry out research. I need to get all opinions in relation to this. Specifically, I am looking at the context within which scientific research in human induced climate change is conducted. This research is considering the pressures that scientists' come under when they are producing research in the climate change field.

2. I am going to be conducting the interview in a semi-structured format.

   - I hope that you do not mind being interrupted to elaborate on a certain point.

   - Any questions you feel that you are uncomfortable in answering please do not hesitate to say so, so that we can move swiftly on.

   - The whole interview should be less than an hour.

3. May I use your name in my write-up? I will send a fully transcribed document of the interview for added comments and permission for the use of your identity later.

4. Just to let you know that any information that needs to be said off the record the dictaphone can be switched off at any moment during the course of the interview.

5. Is there anything that requires further clarification?

Interview Proceedings

SECTION 1

1. I've read your most recent book – Global warming: challenging the conventional wisdom. It is pretty clear where your opinion lies.
   - Could you anticipate any circumstances where it might change?
   - Has anything changed in your article since you have written it?

2. What do you think of the conclusions drawn from authors such as Beder, Karliner, Rowell? Do you feel they have any truth in their argument?

Just a slight change in direction of my questioning. I would like to have your personal opinion on the influence of politics on research.

3. Some research has shown that political values and beliefs (i.e. social, cultural and environmental) are important shaping factors in differences of opinion on global warming.
   - Do you think that this is true? (e.g. Martin Hoffman has speculated that opponents of GW tend to have politically conservative views, whilst proponents of GW happened to be politically liberal)
   - So, would you say that it is possible that scientists' political leaning may influence their views on climate change?

4. Do you think that all scientists produce neutral research in this field?

I would like to ask you a few questions on the policy relevance of scientific work and the global warming scientists themselves.

5. Do you think that global warming scientists should campaign for their work to influence policy? (jeopardise the scientific integrity/neutrality)

6. How do you perceive the role of a GW scientist (to produce results and to advise policy makers?)

7. How have the scientists involved in your books have come to be involved in the IEA?

8. Why do you think some scientists such as Professor Schneider are willing to put their head above the parapet, if you like? (Do you think it is purely because they have a point to make or maybe other factors like funding or publicity are involved?)

9. Do you think that it is for similar reasons that scientists like Fred Singer are able to speak up about the uncertainties of climate change?

10. Why are there so few sceptics in the UK?
    - Why are there so many in the US?
    - Why are they so vocal?
    - Why are there no mainstream sceptics - all those that exist are very vocal in their opinion. This is in complete contrast to protagonists?

SECTION 2

I would now like to talk about publication concerning both scientists research and IEA work.

11. Why do you think some climate change scientists on both sides of the issue engage in debate, or advance a certain perspective other than in academic papers? (e.g. non-peer reviewed journals)

12. Do you know of any climate change scientists that have had their freedom of opinion restricted either within the academic publishing process or generally? So, are they able to say whatever they wish?
    - why do you think this happened?

13. Do some sceptics find it difficult to get their articles published in Britain as there appears to be a strong opposing consensus?

14. One of the scientists I interviewed pointed out that publications for American journals were often restricted if they contradicted American research. Have any scientists you know of come across this?

15. Do you know of any scientists who have come under pressure to dress up their argument/ fill it out/ not to be so direct? Would you say, therefore, that this pressure compromises their research? (to what extent?)

(If appropriate ask) Just so that I could follow this up, is it possible that you could refer me to other opinion-based research. Or, do you even have any offprints?

16. Why do you think that some scientists are accused of jeopardising their scientific integrity if they write for outside the academic publishing press?
    - writing for non peer-reviewed press allows the public to question the integrity of scientists (loose trust in them)?

I would now like to talk about the context of funding within research and the pressure it places on scientists, and if it is o.k to get your opinion on this issue.

17. How do you perceive the whole funding argument?

18. What pressure do you think scientists' come under when they research in this field? Could you categorise them - i.e. funding, career advancement, publishing, (morals)

19. Obviously, some funding is given with the intent of influencing policy – how common do you think that is in climate change research?
    - Are such arrangements effective in your view?

20. Do you think that funding plays any part in scientists' choice to research climate change?

21. Obviously there are pressures to secure funding. In the filed of climate change would you say there is more pressure to secure funding?
    - Where do you think this pressure comes from? (i.e. from your department.)

22. Why do you think scientists funding options ever broaden, or become reduced?
    - Could it be because their perspective/view on a certain subject has changed so therefore they are able to approach certain commercial sponsors or academic or government sponsors (Or, for other reasons also i.e. their academic opinion?/ if they break the prevailing consensus) More accessible to funds.

23. Do you know of any scientists that have had their conclusions in their research influenced by their funding body?

24. I understand that a scientist may choose an area to research because it is interesting. However, is it possible that a global warming scientist may choose or include a research area in a proposal as there may be a better chance of receiving funding?
    - Thus, is it possible that the research question may be subjective? Therefore, does this not colour the objectivity of the rest of the research and its results?

25. Do you think that there is a more market-orientated approach to research now than in the past?
    - Should this continue, or do you think that it could hinder the objectivity of a scientist?
    - Do you think that government backed funding is a greater hindrance to objectivity?

26. Could you conceive of a situation where there are good market reasons for accepting global warming as a serious environmental threat?

SECTION 3

I would like to talk to you about the IPCC and the Kyoto protocol.

27. Is your opinion about the IPCC still the same as it is in your book? You form a very cynical view of the IPCC and their scientists. Do you still hold to this position?

28. Out of interest do you think that they are producing good science?
    - Do you think that different opinions are equally represented?

- Do you think that the IPCC receive sufficient respect?
- Do you think that they are achieving their objectives?

29. One of my interview candidates proclaimed the IPCC process was very different from Boehmer-Christiansen's theory. What's your opinion of them?

30. Following on from this, I would be interested to know what you thought about the Kyoto protocol and whether it is the right approach to dealing with the problem?
    - Do you think that it's doing a good job?
    - What would like to be seen done?

I would now like to ask you some basic facts about the IEA and then your association with scientists.

31. What is the objective of the IEA?

32. What's the objective of the IEA environment group?

33. Who are your publications intended for?

34. Who funds the IEA? - What interest do they have in doing so?

35. Why do the IEA take a similar line of argument against all environmental issues?

36. What is the connection between the IEA and the ESEF?

37. Does the IEA contract scientists?

38. How do they choose which scientists to include/ information to include?

39. Do they contact the scientists or do the scientists contact them?

40. Why are these scientists willing to work for you – surely their academic argument stands strongly enough.

41. Where else do the scientists (those referred to in their text) publish?

42. Protagonists are not as prepared as contrarians to be associated with such groups – why do you think that is?

43. What's your opinion on the GCC?

44. What's your opinion on the IPPC?

45. Why do you think these groups exist?

46. Do you think they are necessary?

End

APPENDIX B

Pilot Interview Proceedings

SECTION 1

The first part of the interview will deal with the science and politics of climate change. As I am interested in scientists' opinions about the greenhouse effect I will begin by asking you a few questions about your view on the subject.

1. Could you tell me whether you believe the enhanced greenhouse effect actually exists? Do you believe that it is man-made?
   - So has this always been your opinion about the greenhouse effect, or has it changed?
   - Why do you think your opinion changed? Is it purely because your knowledge of the subject increased, or were there any other contributing factors? (well, maybe greater possibility to publish papers in this area, better funding options, etc)

2. How have you come to be involved with climate change research? Was it because it was a significant issue, or maybe because your funding options may broaden if you included the subject in your research?
   - (Did funding play any part in your decision to include climate change in your research. – was it a significant factor?)
   - Would you ever consider taking your research in a certain direction, maybe because your funding options may broaden? (Explain why you would consider working in other research areas?)

3. Could you tell me more about the broader aspects of your research?
   For instance, are there any political and economic implications that could be associated with your research, or is this something that you have not really considered?

4. Just a slight change in the direction of my questioning now. What I am very interested in is the policy relevance of your scientific research.
   - Is it important to you that your work is policy relevant?
   - Why is it important to you? / Could you conceive it ever to be important to you?
   - This may sound a little repetitive but do you think that your research has a wider context like engaging in political aspects?

5. I would just like to go into a bit more detail about this and ask to what extent would you want your work to be involved in, or to influence, government policy?
   - Do you think that because you are a scientist that you should, or should not be, involved? (scientific objectivity may be compromised)

6. Obviously, some funding is given with the intent of influencing policy – how common do you think that is in climate change research? – Why?
   - Maybe the people that fund you are looking for a particular payback…would you say that your research, or even your departments research is feeding into the policy process?
   - So, is that the objective of this research? (Then what is?)

7. Out of interest, do you support any environmental NGOs or lobby groups, or have you in the past?
   - What's that group's agenda?
   - So, do you actively support them today? How comes?

8. Some research has shown that political values and beliefs (i.e. social, cultural and environmental) are important shaping factors in differences of opinion on global warming. Do you think that this is true? (e.g. Martin Hoffman has speculated that opponents of GW tend to have politically conservative views, whilst proponents of GW happened to be politically liberal)
   - So, would you say that it is possible that your political leaning may reflect upon your view on climate change?
   - Do you think that everybody produces neutral research in this field?

SECTION 2

I would now like to talk about the feedback that you have received over the years as a result of the publication of your research.

9. Do you know of anyone ever labelling you as having a particular perspective on the greenhouse effect?
   - Yes = Why do you think they came to that conclusion of you, was it, for example, as a result of the publication of a particular article? (Where do you publish your work?)
   - Are you quite happy for people to think that of you? I mean, what particular perspective do you have of yourself? Why is that then?

10. Is it possible that you can engage in debate, or advance a certain perspective other than in academic papers? (e.g. non-peer reviewed journals)
    - Are you, or would you ever be willing to engage in public debate and draw conclusions about the enhanced greenhouse effect?

11. I am very interested in knowing whether it is possible to express your perspective openly in your research? (i.e. suggesting an opinion in the conclusion)
    - Has anyone ever tried to restrict your freedom of opinion either within the academic publishing process or generally? I mean, have you ever felt your work has been censored? So, are you able to say whatever you wish?
    - (why do you think this happened)
    - One of the scientists I interviewed pointed out that publications for American journals were often restricted if they contradicted American research. Have you come across this?
    - Do you know of anyone, or maybe even yourself, who has come under pressure to dress up your argument/ fill it out/ not to be so direct? Would you say, therefore, that this pressure compromises your research? (to what extent?) *(If appropriate) Just so that I could follow this up, is it possible that you could refer me to other opinion-based research. Or, do you even have any offprints?*

12. Why do you think that the likes of some scientists such as Professor Lindzen are willing to speak up about the uncertainties of climate change? (Do you think it is purely because they have a point to grind or maybe other factors like funding or publicity are involved?)
    - Do you believe that it is for the same sort of reasons that protagonists like Professor Schneider are also prepared to put their head above the parapet, if you like?"

SECTION 3

I would now like to talk about the context of funding within research and the pressure it places on scientists, and if it is o.k. to get your opinion on this issue.

13. Obviously there are pressures to secure funding. In your research field would you say there is more pressure to secure funding than in other fields?
    - Where do you think this pressure comes from? (i.e. from your department).
    - Do you think that there is a more market-orientated approach to research now than in the past?
    - Could the pressure ever be that great that you would compromise your preferred research just to get funding?
    - Do you think that this is down to the subject of climate change being different, for instance, it is very controversial?

14. I am very interested to know about the funding process of your research. Could you tell me whether your present research was specifically developed for the research grant you received, or did you approach a number of bodies?
    - Could you tell me a little bit more about this – which body did you say funds you? Is that a commercial/state organisation then?
    - Does this body only fund this type of research?
    - Out of curiosity, do you know of any research in your area that is commercially funded?
    - I would just like to know whether you have ever considered commercial funding, or, for that matter, would you ever think about it?
    - Would you be willing to accept funding from an oil company that you know has a vested interest in proving the greenhouse effect is not an important problem?

15. Why do you think that scientists funding options ever broaden, or become reduced? (Could it be because their perspective/view on a certain subject has changed so therefore they are able to approach certain commercial sponsors (or, for other reasons, i.e. their academic opinion?)
    - Do you feel that this has personally affected you? (i.e. have your funding options ever increased or decreased?) Do you think this could be because of your opinion on the subject?)

16. Would your perspective on the subject of the greenhouse effect influence your conclusions you draw in your research? (Could the body that funds you have any influence over the conclusions you draw?)

17. Just to bring the last couple of topics together, I would like to ask if you could weigh up, or categorise if you like, the types of pressures involved in research? I mean, what are the greatest pressures in your research? Is it at all possible to categorise them? (i.e. funding, career advancement, publishing, (morals)

18. I understand that you may choose an area to research because it is interesting. However, is it possible that you may choose or include a research area in a proposal as there may be a better chance of receiving funding?
    - Thus, is it possible that the research question may be subjective? Therefore, does this not colour the objectivity of the rest of the research and its results?

Subsection 3

19. As we have a few minutes left, if you don't mind could I ask you what is your general opinion about the IPCC?
    - For instance, do you think that they are achieving their objectives?
    - Are they producing good science?
    - Do you think that the IPCC receive sufficient respect?
    - Do you think that different opinions are equally represented?

20. Following on from this, I would be interested to know what you thought about the Kyoto protocol and whether it is the right approach to dealing with the problem? (in

other words, in your opinion, is it doing a good job? – politically, opinion on America)

- For example do you think that enough being done within the right timescales? –
- What would like to be seen done?

End

APPENDIX C

Interview proceedings

1. Is it possible to record this interview by using a dictaphone?

2. I am interviewing you because …

3. My research is looking at the context within which scientific research in human induced climate change is conducted.
   I am basically researching the pressures that scientists' come under when they are producing research in the climate change field.

4. I am going to be conducting the interview in a semi structured format.

   - Any questions you feel that you are uncomfortable in answering please do not hesitate to say so, so that we can move swiftly on.

   - The whole interview should be less than an hour.

5. I will not use your name in my write-up. I will send a fully transcribed document of the interview for added comments or if you wish to remove anything you said.

6. Any information that needs to be said off the record the dictaphone can be switched off at any moment during the course of the interview.

7. Is there anything that requires further clarification?

Appendix C

Interview Proceedings

SECTION 1

The first part of the interview will deal with the science and politics of climate change. As I am interested in scientists' opinions about the greenhouse effect I will begin by asking you a few questions about your view on the subject.

1. How serious do you think the problem of the enhanced greenhouse effect is?
   - So has this always been your opinion about the enhanced greenhouse effect, or has it changed?
   - Why do you think your opinion changed? Is it purely because your knowledge of the subject increased, or were there any other contributing factors? (maybe greater possibility to publish papers in this area, better funding options etc)

2. How have you come to be involved with climate change research? Was it because it was a significant issue, or maybe because your funding options may broaden if you included the subject in your research?
   - (Did funding play any part in your decision to include climate change in your research. – was it a significant factor?)
   - Would you ever consider taking your research in a certain direction, maybe because your funding options may broaden? (Explain why you would consider working in other research areas?)

3. Could you tell me more about the broader aspects of your research? For instance, are there any political and economic implications that could be associated with your research, or is this something that you have not really considered?

4. Just a slight change in the direction of my questioning now. What I am very interested in is the policy relevance of your scientific research.
   - Is it important to you that your work is policy relevant?
   - Why is it important to you? / Could you conceive it ever to be important to you?
   - This may sound a little repetitive but do you think that your research has a wider context like engaging in political aspects?

5. I would just like to go into a bit more detail about this and ask to what extent would you want your work to be involved in, or to influence, government policy?
   - Do you think that because you are a scientist that you should, or should not be, involved? (scientific objectivity may be compromised)

6. Obviously, some funding is given with the intent of influencing policy – how common do you think that is in climate change research? – Why?
   - Maybe the people that fund you are looking for a particular payback…would you say that your research, or even your departments research is feeding into the policy process?
   - So, is that the objective of this research? (Then what is?)

7. Out of interest, do you support any environmental NGOs or lobby groups, or have you in the past?
   - What's that group's agenda?
   - So, do you actively support them today? How comes?

8. Some research has shown that political values and beliefs (i.e. social, cultural and environmental) are important shaping factors in differences of opinion on global warming. Do you think that this is true? (e.g. Martin Hoffman has speculated that opponents of GW tend to have politically conservative views, whilst proponents of GW happened to be politically liberal)
   - So, would you say that it is possible that your political leaning may reflect upon your view on climate change?
   - Do you think that everybody produces neutral research in this field?

9. Why do you think that the likes of some scientists such as Robert Balling are willing to speak up about the uncertainties of climate change? (Do you think it is purely because they have a point to grind or maybe other factors like funding or publicity are involved?)
   - Do you believe that it is for the same sort of reasons that protagonists like Professor Schneider are also prepared to put their head above the parapet, if you like?"
   - Why do you think that there are so few sceptics in the UK, and that most of them are concentrated in the US?

(Julian Morris from the IEA claimed that there is a 'homogenous scientific culture here. There is a less diverse source of funding here, whereas in the US there is a decentralisation of funding which creates, or allows for different visions'.) He believed that that the decentralisation of funding in the US allows for a greater degree of interdependence. Do you think that is true?

- What factions do you identify in the debate? (How do you envisage the various camps of scientists?)
- Julian Morris also believed that UK scientists are more in favour of government intervention. The government is involved in science and it vaguely is in control of science and its effects it might have on society. From your experience, do you think that this is true?

SECTION 2

I would now like to talk about the feedback that you have received over the years as a result of the publication of your research.

10. Do you know of anyone ever labelling you as having a particular perspective on the greenhouse effect?
    - Yes = Why do you think they came to that conclusion of you, was it, for example, as a result of the publication of a particular article? (Where did you publish your work?)
    - Are you quite happy for people to think that of you? I mean, what particular perspective do you have of yourself? Why is that then?

11. Would you be prepared to engage in debate, or advance a certain perspective other than in academic papers? (e.g. non-peer reviewed journals)
    - Would you engage in public debate and draw conclusions about the enhanced greenhouse effect?

12. I am very interested in knowing whether it is possible to express your perspective openly in your research? (i.e. suggesting an opinion in the conclusion)
    - Has anyone ever tried to restrict your freedom of opinion either within the academic publishing process or generally? I mean, have you ever felt your work has been censored? So, are you able to say whatever you wish?

(why do you think this happened)

- One of the scientists I interviewed pointed out that publications for American journals were often restricted if they contracted American research. Have you come across this?
- Do you think that sceptics find it difficult to get their research published in UK journals because there appears to be is a strong opposing consensus?
- Do you know of anyone, or maybe even yourself, who has come under pressure to dress up your argument/ fill it out/ not to be so direct? Would you say, therefore, that this pressure compromises your research? (to what extent?)

  (If appropriate ask) Just so that I could follow this up, is it possible that you could refer me to other opinion-based research. Or, do you even have any offprints?

SECTION 3

I would now like to talk about the context of funding within research and the pressure it places on scientists, and if it is o.k. to get your opinion on this issue.

13. Obviously there are pressures to secure funding. In your research field would you say there is more pressure to secure funding than in other fields?
    - Where do you think this pressure comes from? (i.e. from your department.)
    - Do you think that there is a more market-orientated approach to research now than in the past?

      <u>- Do you think that the power in the debate is concentrated in those who have the economic control?</u>

      <u>- Do you feel therefore that scientific ability could be trade, something which can be marketed, or you could sell?</u>
    - Could the pressure ever be that great that you would compromise your preferred research just to get funding?
    - Do you think that this is down to the subject of climate change being different, for instance, it is very controversial?
    - A social scientists has argued that protagonists are pressured to conform to the conventional wisdom in terms of getting funding for research. Do you think that this is true?

- Professsor Reginald Newall claimed that it is very difficult to go against the status quo because funding dries up. Do you think this is true? Or is there peer pressure to conform. In other words, do you think that social context influences scientists interpretative procedure?
- Do you think that sceptics research is influenced by funding?

14. I am very interested to know about the funding process of your research. Could you tell me whether your present research was specifically developed for the research grant you received, or did you approach a number of bodies?
    - Could you tell me a little bit more about this – which body did you say funds you? Is that a commercial/state organisation then?
    - Does this body only fund this type of research?
    - Out of curiosity, do you know of any research in your area that is commercially funded?
    - I would just like to know whether you have ever considered commercial funding, or, for that matter, would you ever think about it?
    - Would you be willing to accept funding from an oil company that you know has a vested interest in proving the greenhouse effect is not an important problem?

15. Why do you think that scientists funding options ever broaden, or become reduced? (Could it be because their perspective/view on a certain subject has changed so therefore they are able to approach certain commercial sponsors (or, for other reasons also i.e. their academic opinion?)
    - Do you feel that this has personally effected you? (i.e. have your funding options ever increased or decreased?) Do you think this could be because of your opinion on the subject?)

16. Would your perspective on the subject of the greenhouse effect influence your conclusions you draw in your research? (Could the body that funds you have any influence over the conclusions you draw?)
    - Would you be willing to change your line of argument (for want of a better phrase) if sufficient evidence proved your initial work to be wrong?

17. Just to bring the last couple of topics together, I would just like to ask if you could weigh up, or categorise if you like, the types of pressures involved in research? I

mean, what are the greatest pressures in your research? Is it at all possible to categorise them? (i.e. funding, career advancement, publishing, egoism, (morals)

- One of the scientists I interviewed claimed that the climatic research unit emphasised the importance of climate change to achieve greater funding? Do you agree? (they claimed that they are given specific guidelines on what is required)

18. I understand that you may choose an area to research because it is interesting. However, is it possible that you may choose or include a research area in a proposal as there may be a better chance of receiving funding?
    - Thus, is it possible that the research question may be subjective? Therefore, does this not colour the objectivity of the rest of the research and its results?
    - Do you think that age has a role – i.e. are the pressure the same throughout your career?

Subsection 3

19. How do you perceive the IPCC? What is your opinion about the IPCC?
    - What do you think of B-C conspiracy theory?
    - What's the power/influence structure within the IPCC? (one scientists claimed that you have to be vocal so to get your opinion represented)
    - Do you think that different opinions are equally represented? I mean how influential are the sceptics in the IPCC?
    - Are they producing good science?
    - Do you think that the IPCC receive sufficient respect?
    - Do you think that they are achieving their objectives?

20. Do you think that the Hadley Centre or MET office only employs protagonist scientists? (Do all those who are employed by the Hadley Centre share the same opinion about the enhanced greenhouse effect?

21. Does the context of the Hadley Centre have any sort of influence over your or any body else's interpretative procedure?

22. Following on from this, I would be interested to know what you thought about the Kyoto protocol and whether it is the right approach to dealing with the problem? (in other words, in your opinion, is it doing a good job? – politically, opinion on America)
    - For example do you think that enough being done within the right timescales?
    - What would like to be seen done?

End

APPENDIX D

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January 2000

Dear Professor/Doctor,

I am currently undertaking a PhD at the University of Leeds investigating influence in climate change scientists' research. The project, which is funded by the School of Geography, is exploring attitudes towards the enhanced greenhouse effect, considering not only individual scientist's convictions, but also the pressures they might have faced as their work has evolved. There is little analysis of scientists researching the phenomenon especially when their work has considerable political, social and economic consequences. Thus, I am particularly keen to look at the context in which research into climate change is conducted.

To ensure that I represent the views of climate change scientists accurately I am undertaking a programme of semi-structured interviews with individual researchers. I would very much like to include your opinion within this project and talk to you about the pressures involved when undertaking research in the climate change area and would value your view regarding the utilisation of your work. I will contact you in the next few days by e-mail to arrange an interview that will be convenient to you.

I can assure you that you will not be identified without your permission.

If you would like any further information about this research project, please do not hesitate to contact me on 0113-233-6757 or pgam@geog.leeds.ac.uk. I look forward to talking to you soon.

Yours sincerely,

Anna Matthews

APPENDIX E

UK and US Interviewees

1) Interviewee A: Climate Scientist - US, Doctor, University – Mainstream, Protagonist

2) Interviewee B: Climate Scientist – US, Professor, University – Mainstream, Protagonist

3) Interviewee C: Climate Scientist – US, Professor, University – Mainstream, Protagonist

4) Interviewee D: Climate Scientist – US, Professor, University – Mainstream, Protagonist

5) Interviewee E: Climate Scientist – UK, Doctor, Government – Mainstream, Protagonist

6) Interviewee F: Climate Scientist – UK, Doctor, Government – Mainstream, Protagonist

7) Interviewee G: Climate Scientist – UK, Doctor, Government – Mainstream, Protagonist

8) Interviewee H: Climate Scientist – UK, Professor, University – Public, Protagonist

9) Interviewee I: Climate Scientist – UK, Doctor, University – Mainstream, Protagonist

10) Interviewee J: Climate Scientists – UK, Doctor, University – Mainstream, Protagonist

11) Interviewee K: Climate Scientist – UK, Doctor, University/(Business) – Public, Sceptic

12) Interviewee L: Climate Scientist – US, Doctor, University – Public, Sceptic

13) Interviewee M: Climate Scientist – US, Doctor, University – Public, Sceptic

14) Interviewee N: Climate Scientist – US, Professor, University - Public, Sceptic

15) Interviewee O: Social Commentator - US

16) Interviewee P: Social Commentator - US

17) Interviewee Q: Social Commentator - US

18) Interviewee R: Social Commentator - UK

19) Interviewee S: Social Commentator - UK