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Climate Change and Knowledge Communities

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Climate Change and Knowledge Communities

M.C. Gallastegui¹ and Ibon Galarraga²

Climate change is a global problem whose particular characteristics mean that public-sector policy is fundamental in tackling it: a public-sector policy implemented world-wide that requires the co-operation of a large number of very different stakeholders. Innovative instruments are needed that can overcome the difficulties inherent in a global challenge of this magnitude. This paper looks at climate change as an excellent case in point of how knowledge communities can effectively help to spread learning processes and paradigm shifts. A central role in the globalisation of knowledge of this problem over the past few decades has been played by the Intergovernmental Panel on Climate Change (IPCC), which has acted as a knowledge community and a catalyst for the globalisation of learning. It is not the only community that has contributed to providing both the general public and public-sector policy-makers all over the world with a better understanding of the problem of climate change and the options available for tackling it, but it is without doubt one of the most significant.

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1. Introduction

As scientific evidence grows that atmospheric concentrations of greenhouse gases (GHGs) are already near or above levels that pose dangerous risks of warming over the long term, policymakers are increasingly focusing on strategies to quickly reduce emissions across as many sectors as possible. In particular, policies for Reducing Emissions from Deforestation and Forest Degradation (REDD) offer an immediate opportunity to mitigate a major share of global greenhouse gas emissions at relatively low estimated costs (Stern 2008).³ International forest carbon efforts could also offer an attractive “wooden bridge” for reducing near-term emissions while buying time to adapt to a low carbon future (Chomitz 2006). In the absence of certainty over long-term emissions targets, early emissions reductions also have particular value as a global insurance policy that keeps options open to avoid potentially much greater economic costs and climate risks in the future (Fisher et al. 2007).

The 1990s saw major changes in the economic growth models used generally for theoretical and empirical analyses.

Authors such as Romer (1986) and Lucas (1988) showed how external economies of scale (Romer 1986) and knowledge spillover effects (Lucas 1988) could increase the returns on accumulated private human capital. This effect, in turn, enabled long-term endogenous growth of economies to be encouraged.

The idea that is to be stressed here is that knowledge is increasingly productive. This idea is based on the following argument: the creation of new knowledge by some corporations has positive external effects on others, increasing their potential for knowledge production, because it is impossible for all knowledge to be patented or kept secret. As a corollary it can be concluded that investing in knowledge gives rise to a natural external effect which, contrary to what economic theorists have long maintained under the name “law of decreasing marginal productivity”, means that we now find that on an aggregate level knowledge has increasing marginal productivity.

When this increasing marginal productivity for the intangible capital good known as scientific knowledge is substituted for the assumption of decreasing marginal productivity, the implications are far-reaching.

The most important implication can be put as follows: there is no reason why the economy should not be able to expand in terms of GDP if physical capital is combined with knowledge and science. This illustrates how little and how late we economists have included the importance of non man-made capital (i.e. natural capital or environmental assets) into our analyses. It also illustrates how short-sighted we have been in failing to realise that growth cannot be sustainable if non man-made capital is overexploited or managed inefficiently. But leaving aside this unavoidable but, we believe, accurate comment, the need for knowledge and science to ensure GDP growth must be stressed.

When we speak of differences in technology between countries, the knowledge and science to which we refer is not usually general knowledge but the knowledge of specific people or of a specific

³ The latest IPCC report estimates that destruction of tropical forests and peat lands contributed 17.5% of global anthropogenic GHG emissions in 2004 – greater than the entire global transport sector, and about the same scale as all fossil fuel emissions from China or the United States (Rogner et al. 2007). More recent data put this share at 12% and, likely, higher depending on the share of peat fires on unmanaged lands attributed to human activities (WRI CAIT, forthcoming; Houghton 2008).

sub-group of people who have dedicated themselves to the acquisition, production and generation of knowledge.

In this context G. Becker of the University of Chicago developed a whole theory based on “human capital” which is still relevant today in explaining many differences in growth, productivity and earnings between economies or geographical areas. Thanks to him, we know that it is the sub-groups of people who dedicate themselves to the production and generation of knowledge that really matter. A prerequisite for such groups is the acquisition of knowledge through learning or research processes.

These sub-groups can be called “knowledge communities”, and their endowment is known as “human capital”, an asset that can be understood in aggregate form (e.g. at national level) or disaggregate form (at industrial level). The next section outlines some ideas as to why human capital is important for economic growth.

2. The Importance of Human Capital

As mentioned above, many recent economic models feature human capital as a driving force for growth. The introduction of this variable into theoretical models means that other aspects of our analysis must be developed.

First of all we must stop and consider how the different levels of human capital affect levels of production, and secondly we must establish a model to show how the time allocated by each person affects precisely the accumulation of this capital in the form of knowledge.

But in the context of this paper other aspects also need to be highlighted. On the one hand, in the accumulation of physical capital there is no counterpart to the group social activity that takes place when human capital accumulates. On the other hand the analyses carried out as a result of Becker’s pioneering work draw a distinction between “internal effects” and “external effects”.

The internal effects of human capital can be thought of as the way in which investment in human capital translates into returns which are felt by individuals and their immediate families (salary effects, productivity, earnings throughout the life-cycle, etc.), while external effects are not appreciable at micro-economic level but are visible at aggregate level. In this regard, Lucas estimates the percentage of variation in US GDP due to the external effects of human capital as 0.4%, a figure which is certainly large enough to merit being taken into account.

Another point of interest of this paper is the following: in the context of economics, when we consider a technology through which the average skill level of a group of people affects the productivity of each individual within that group the economic unit of analysis need not always be the national economy. Indeed, much smaller units such as regions, cities, communities, etc. may be used (which means that percentage of GDP is not a suitable variable). The idea is to capture the way in which the different groups that influence their respective productivity levels interact with one another.

Another factor that must be taken into account (because it conditions the way in which the analysis must continue) is that many external effects of knowledge can be internalised in small groups of people, e.g. companies or families, though this is not necessarily the case. At the other end of the spectrum, certain discoveries may even be classed as having “common ownership”, i.e. once the

knowledge in question has been created it is not considered as the property of a single owner or institution (company, family, etc.) but rather of a whole group of individuals and/ or institutions.

2.1. The Learning Process

Most of what we learn is learned from others. Usually we pay our “teachers” directly, but there are also other, indirect forms of payment. Consider, for example, the option of accepting lower wages in exchange for benefiting from the knowledge held at the company where one works. However, most benefits are obtained free of charge and in ways which are mutually beneficial and interactive.

Such “external effects” can be thought of as “learning by osmosis”. This type of learning is common throughout the arts and sciences, i.e. in what we might call “creative occupations”, and the history of intellectual development is to some extent the history of these effects.

One final idea remains to be added: for the most part, or at least to a large extent, economic activity is just as creative as art and science (Jacobs 1969). As Lucas puts it, “New York City's garment district, financial district, diamond district, advertising district and many more are as much intellectual centers as is Columbia or New York University”.

The specific ideas shared in these districts are different from those shared in academic circles, but the process is quite similar: a group of people doing practically the same thing, each emphasising his/her own originality and uniqueness.

A knowledge community can therefore be thought of merely as a focal point where creativity finds ideal conditions for growth and where the learning process is not necessarily formal, but may take place through the assimilation and spillover of creative attitudes and activities.

For these knowledge units to bear fruit it is essential that they should contain a mix of cultures, religions, races and genders. They must be communities where everyone learns from everyone else and where, ultimately, confidence rules because reference points can be found regardless of who or what organisation needs knowledge or wishes to contribute to knowledge.

This idea is relevant to the specific case examined here because we are attempting to show that climate change has given rise to a knowledge community in which the characteristics mentioned above can be identified, among others.

Our knowledge of climate change, its causes, its implications and its potential solutions is accompanied by an effort to pool knowledge from many different disciplines, areas of basic and applied science, institutions and countries. The blending and sharing of the achievements of each party has been a constant feature in that effort ever since the United Nations set up the Intergovernmental Panel on Climate Change (IPCC). As explained in Section 4 below, the IPCC has conducted exhaustive studies into the problems and causes of climate change. But first let us analyse other ideas which may also be useful in explaining why a group of “sophisticated” consumers is a prerequisite for the success of certain technological developments and communities.

2. The Knowledge Economy (The “Weightless Economy”)

In 2000 Danny T. Quah wondered⁴ about the reasons for certain developments which now seem easier to explain but which in their day required in-depth economic analysis.

Quah believes that the growth of the “weightless economy” explains why a special dynamic has arisen in the Internet economy, with online trading and an increasingly strong shift towards significant levels of trade based on mobile telephones.

The clearest example of modern technology can be found in ICTs, which gave rise to what is known as the “productivity paradox”, though the explanation of that paradox lies outside the scope of this paper.

However, one aspect of Quah’s pioneering work that is of interest here is his definition of the “weightless economy”, which does not coincide in all points with the definition of the knowledge economy. To understand the difference, consider the following stylised economic growth process:

Skills, education and everything else involved in human capital and in the working population entail an allocation of time and energy between alternative uses. Thus, individuals who are “highly trained” or have “skills” may work in sectors that produce final goods and services for end users, or they may work as researchers, scientists, engineers, etc. The ideas that they generate provide a fundamental basis for growth and, in the terminology used by Quah, constitute intellectual assets subject to economic and social protection through intellectual property rights.

If ideas were transmitted through a free-market, their price would tend to be equal to the marginal cost of reproducing them. This, in general, would give a price close to zero, which would therefore not provide any incentive to make new discoveries.

But in the new economy the process of protecting ideas through intellectual property rights works differently. By contrast, consumers directly confront those sectors that produce knowledge, which means basically the ICT sector (the Internet, telecommunications, intellectual assets in the broad sense including patents, music, entertainment videos, advice on health matters, etc, databases, electronic libraries, etc).

In all these cases, end users interact with products directly. Knowledge is incorporated not into the production process but into the end products: this is a major difference, and for the process to work knowledge must also be transferred to users. In other words, users must be sophisticated enough to appreciate, and therefore to demand and to be willing to pay for, knowledge-generated products. This contrasts sharply with, for example, an economy in which scientific and technological progress is driven by technological improvements in manufacturing industry.

In a weightless economy, in which knowledge is incorporated directly into end products, the way in which demand is set up is crucial. Consumers must be capable of accepting complex, sophisticated new ideas, new products, goods and services.

The size of the market is also crucial. In terms of profit, whoever achieves the biggest market wins: local markets are too restrictive, so global markets must be sought.

The reader may be wondering how these developments are connected to the knowledge community established around the problem of climate change. The link can be found in the type of

⁴ In a lecture at the Bilbao Stock Exchange.

sophisticated alternatives being developed as potential solutions to mitigate the harmful consequences of climate change: houses that run on solar power, much more selective recycling, less pollutant products such as electric cars, carbon capture and sequestration, etc. Without sophisticated consumers well aware of biophysical problems many solutions are unlikely to be put into practice. Once again knowledge, in this case on the part of consumers, is crucial in responding to the global challenge of climate change.

The rest of this paper focuses on the problem of climate change and seeks to provide a simple economic characterisation for it, to show how the transfer of knowledge and the achieving of international agreements work.

4. Economic Characterisation of the Problem of Climate Change

4.1. The Basics

Government intervention to attempt to prevent the effects of GHG (especially CO₂) emissions on the Earth's climate is based on a sound foundation. From an economic viewpoint, however, certain points need to be taken into account.

The Earth's climate can be modelled as a public good. It meets the two requirements specified by Nobel laureate Paul A. Samuelson⁵: non rivalry and non exclusion in consumption. It affects us all and no-one can be excluded from using it. Thus, in line with Samuelson's thinking, we might expect it to be undersupplied, which would result in the existence of global warming or climate change⁶.

Moreover, the Earth's climate is a global public good. CO₂ emissions are what is known as "perfectly mixed" emissions: what matters most is the total amount of emissions generated all over the world, and not their point of origin. They are also persistent (i.e. the atmosphere is incapable of turning all CO₂ emissions into harmless forms), so it follows that when we analyse the problem we must take into account not only the flow (emissions) but also the stock (gases accumulated in the atmosphere which are not absorbed or assimilated) of pollution. An economic analysis of climate change therefore requires a dynamic, inter-temporal approach which must explicitly factor in the existence of uncertainty. It is also important to bear in mind that today's pollution is not produced today, but rather is the result of the build-up of gases over many decades. It is therefore essential not to put off until tomorrow measures to mitigate and solve the problem: urgent action is needed.

Another way of looking at the problem is to consider that the atmosphere is used by human beings as a free waste dump. Because the services provided by the atmosphere, and by the environment in general, are free they are overused: not charging for the consumption or use of goods encourages their use to an extent greater than that which is economically efficient.

Moreover, the fact that these are "perfectly mixed" emissions means that their sources are less important than their total amount. Countries that emit CO₂ harm not just themselves but also the people of other countries. To put it more technically, there are external effects which are reciprocal in nature.

⁵ Winner of the Nobel Prize in Economics in 1970.

⁶ The fact that the Earth's climate is a global public good does not imply that the effects of climate change must also be considered as a public good. Those effects may be unevenly distributed across geographical areas which vary according to the extent of the temperature increases involved.

Characterising the Earth's climate and, by contrast, climate change as a public good (bad) or a situation in which there are harmful, reciprocal external effects between countries leads inevitably to the following corollary.

“The workings of the market are unable to bring about an efficient allocation in the presence of public goods (bads) and when there are external effects in the economy. Global warming, the misuse of the atmosphere as a dumping ground for GHGs, is therefore a foreseeable consequence and not the result of bad luck or inevitable, “natural” changes in climate”.

Since it is foreseeable that countries, economic agents and, ultimately, human beings, will abuse the atmosphere and the environment and thus cause undesirable anthropogenic effects in the Earth's climate, it can be concluded that the only way of preventing such abuse is through regulation by the public authorities.

Regulation can be applied in many different ways. If we concentrate on emission control and/ or mitigation the measures adopted must meet two essential requirements:

- i) they must be global in the sense that they must affect all the countries in the world;
- ii) they must also be global in the sense that they must cover all sectors of production and consumption (emissions are produced by all sectors, including domestic and residential).

On the other hand there is a basic equation which, in its simplest form, reads as follows:

$$\text{CO}_2/\text{output} = \text{Efficiency (energy/output)} * \text{Carbonisation (CO}_2/\text{energy)},$$

From this it can be deduced that regulating climate change calls for a decarbonisation of the economy and for energy efficiency.

Both these requirements may be expensive to achieve, so the challenge is to carry them out in such a way as to minimise transition costs, harmful economic adjustments, impacts on poorer countries and the impacts of the “losers” on the wealthier countries, and to assure the welfare of future generations.

Achieving regulation in such a way as to minimise anthropogenic impacts on the Earth's climate (a public good that must be safeguarded) is a complex business, as the basic characteristics indicated above make clear.

The global nature of the problem means that the solution needs to be negotiated worldwide, in a process of negotiation that can tackle the distribution of the benefits and costs arising from co-operation.

However, co-operation is extremely hard to achieve. Consider the following points:

It is individually rational not to take part in control or mitigation policies implemented by other countries (which goes some way towards explaining the current positions of the USA, China, India and Australia).

Negotiation costs are very high, because there are many countries involved and the costs of controlling the damage caused by climate change and monitoring mitigation efforts are distributed unevenly.

There is a high degree of uncertainty. For example, mitigation costs are incurred immediately while the benefits of preventing or mitigating climate change are felt only in the future.

The likelihood of deception and nonfulfilment is high.

There is no international body that can guarantee the fulfilment of the agreements reached.

Moreover, numerous actions are required to achieve decarbonisation and efficiency. Energy sources not based on fossil fuels must be used, technological improvements must be introduced to foster energy efficiency, changes in consumer habits must be encouraged and carbon capture and sequestration (CCS) technologies must be researched and implemented.

Mitigating emissions, changing consumer habits, shifting to less harmful energy sources, conducting research in CCS technologies, etc all have internal economic impacts of their own, since the economy is a mechanism that must be analysed from the viewpoint of general equilibrium. Everything influences everything else.

The production of renewable energy sources such as biofuels, for instance, gives rise to changes in the prices of basic products such as corn, and increases the price of edible oils and other foodstuffs.

The new transport policies that must be implemented are another case in point: they are bound to have an impact on the automotive industry, on the mobility of economic agents, on the prices charged for road journeys, etc.

New consumer habits have implications for the service sector, and it is estimated that the market for low carbon emission products could be worth up to €500 billion by the year 2050.

Nor should we forget the implications of the appearance of new opportunities or niche markets for business, new investment opportunities, new technological advances and new products which may affect insurance companies, financial analysts, investment firms, etc.

In short, mitigation and regulation measures must be considered in a highly general context which includes all their potential knock-on effects.

4.2. The Instruments Available

Once it is accepted that there is a need for regulation and for global agreements, and given the lack of any international regulatory body, co-operation is the only way in which efficient results can be assured. However, as mentioned above, co-operation is hard to achieve because it is individually rational to act non-co-operatively. The political efforts required to achieve co-operation are huge but fundamental. "Compensations" and "transfers" are crucial elements in this process.

Furthermore, the instruments to be used in mitigating emissions must be chosen with great care.

From an economic viewpoint, once it is accepted that efficiency is unattainable, the use of environmental policy measures to achieve objectives at minimal cost is proposed. The scenario is such that objectives must be selected by society through its political representatives (based on scientific reports). These objectives constitute minimum levels (e.g. keeping the average temperature of the planet from increasing by more than 2°) which must be reached in such a way that the costs inevitably entailed by emission mitigation processes are minimised.

It has been amply proven that market instruments (prices, taxes, creation of markets) are cost-effective, but it is clear for all to see that they must be designed and implemented with the maximum rigour and based on reliable, comprehensive studies.

In short, maintaining the Earth's climate calls for well-designed, well-planned, well-implemented government intervention. The actions taken must be global, the instruments used must be cost-effective and uncertainty must be explicitly taken into account.

To take our examination of the matter of instruments a little further, let us now pause briefly to consider the Emissions Trading Scheme (ETS) selected as part of the package of measures introduced by the Kyoto Protocol, which will be considered in more detail in the next section.

The ETS covers only part of the CO₂ emissions produced in the EU. Specifically, it affects emissions from around 9000 facilities in the energy, cement, glass, ceramics, steel and paper industries. In all, the emissions covered amount to around 45% of the total. At European level electricity generation from fossil fuels is the biggest individual cause of CO₂ emissions from industry. It involves large, static emission sources.⁷

Economic analysis suggests that the relative effectiveness of this policy instrument⁸ will depend on the context in which it is used. Specifically, the relative extent of uncertainty as to the benefits and costs of reducing emissions may tip the balance in favour of mechanisms such as the ETS or in favour of taxes/subsidies. The arguments in support of each option can be summed up as follows:

a) If a tax on CO₂ is set too low, too much CO₂ will be emitted. But because the environmental damage done by GHGs builds up over time, short-term excesses have little influence on the overall path of global warming: the tax can be raised before much damage is done to the environment. By contrast, setting the wrong levels in emission trading may cause the price of permits to rocket or plummet, with immediate, costly economic consequences. These markets usually have volatility levels in excess of 40%, so this may translate into significant fluctuations in inflation or domestic spending, and may slow down investment in clean technologies. On the other hand, in an emission trading market inflation is adjusted for automatically, which is not the case when taxation is used.

b) Taxation provides a clear lower threshold for CO₂ prices and thus a minimum return for any innovation. By contrast, in an emissions trading market an invention that cuts CO₂ emission costs could force the price of trading rights down and thus reduce the return on investments.

c) A tax on CO₂ raises tax revenue. Governments can use this additional revenue to cut other, less efficient taxes and thus reduce the financial cost of reducing emissions (the double dividend hypothesis). Alternatively, they can use the revenue to compensate those people (e.g. the poorest members of society) who are affected disproportionately by increased fuel costs. Cap-and-trade systems can do likewise, provided that the initial assignation of emission rights takes place by auction (the form recommended by economists). In practice, however, political considerations have resulted in trading rights being given away at the initial stage of the process.

⁷ The transport and residential sectors and others remain outside the ETS. This is due largely to how difficult they are to regulate in view of their disperse nature, the fact that they are mobile emitters and other considerations. These characteristics could be taken as an argument for a tax on CO₂ instead of or in addition to a cap-and-trade system.

⁸ The sectors covered by the ETS operate on a cap-and-trade basis, under which the relevant authority sets the total admissible volume of emissions (the cap) and issues the corresponding number of CO₂ credits. From there on the working of the market itself (trade) guides those credits into the hands of those willing to pay most for them (i.e. the corporations with the biggest emission reduction costs). For the same reason, firms with lower reduction costs sell their rights (on which they place less value) and cut their emission levels. The means that emissions are reduced at the lowest possible cost.

Another possible form of mitigation is to use standards, i.e. to establish caps on CO₂ emission levels. This can force firms to make changes, for instance, in electricity generation technology. Thus, a cap of 600g CO₂/kWh will remove a coal-fired power station from the grid and encourage its owner to replace it with a natural gas fired station. A still more restrictive cap of 400g CO₂/kWh will remove a conventional gas-fired power station from the grid and force the owner to install CO₂ capture technology.

These three instruments can be used jointly or separately, so there is a wide range of mitigation options. Some degree of substitution between them is also possible. For example, replacing coal-fired power stations by cleaner, gas-fired facilities begins to make sense at CO₂ prices in excess of €3/ t CO₂, regardless of whether or not there is a limit on quantities. Similarly, a restrictive limit may be compatible with a low level of taxation on CO₂. Note, however, that although the same level of mitigation may be achieved by each of these three instruments the cost of electricity will not be the same in all three cases.

There are other complications⁹ that affect environmental policies on climate change which are not considered here due to lack of space, but which also have a substantial effect on the complex matter of policy design.

Moreover, aside from specific environmental policies there are measures typical of fiscal (taxes & subsidies) and financial (bonds, insurance) policies that can also be used in the struggle against climate change.

5. Climate Change Policy in International Forums

5.1. Kyoto & International Negotiations

Given the complexity of climate change and the policies for dealing with it, we felt that we should devote a section of this paper to outlining the course that matters have taken on the international stage in regard to the problem.

Concern for changes in climate patterns were first aired at the World Climate Conference in Geneva (Switzerland) in 1979. The main landmark dates since then are the following:

- the Greenhouse Gas Conference in Austria in 1985;
- the founding of the Intergovernmental Panel on Climate Change in 1988; and
- the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) at the Rio Summit in 1992 (though it came into force in 1994).

The "Kyoto Protocol", to which we have referred above, was drawn up in 1997 and takes its name from the Japanese city in which it was signed. It is a major international agreement that sets industrialised countries a target of reducing their greenhouse gas (GHG)¹⁰ emissions by 5.2% on 1990

⁹ Cost benefit functions tend to be highly non linear, so it is inadvisable to trust calculations based on average or expected levels. Environment policies entail major irreversibilities, which interact with uncertainty, sometimes in a complex fashion. Environment policies cover long time-frames, which exacerbates the uncertainty concerning their costs and benefits and greatly increases uncertainty as to what the right discount rate might be.

¹⁰ The main GHGs are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆).

levels in the period 2008-2012. 38 countries initially signed up to the protocol. Under the distribution of efforts to meet this objective, the EU as a whole was set a target of reducing emissions by 8%. The way in which this target was then broken down among Member States resulted in Spain being allowed to increase its emissions by 15%.

The Protocol established a legal framework for a commitment to reduce GHG levels which is binding on those countries which approved and then ratified it. Mechanisms were also established for achieving the targets set.

The Kyoto Protocol draws a distinction between "Annex I" countries (industrialised countries which are legally obliged to implement the reductions agreed upon once they have ratified the protocol) and the rest, which are to make voluntary commitments. The process of negotiation focused mainly on working out conditions under which non-Annex I countries could make a significant contribution to achieving target levels. The conditions established cover many aspects, from the distribution of the financial burden among developed countries (which are historically responsible for most emissions) to effective technology transfer systems, the role of deforestation and the establishment of funding for adaptation to changes which are already taking place as a result of climate change and changes in which will be unavoidable in the coming years.

Among the instruments established under Kyoto are the so-called "flexible mechanisms", three market-based mechanisms (one of which is discussed above in Section 4) which go beyond national level policies in each individual country:

- Emissions Trading

The best example of this mechanism is the European Emissions Trading System (ETS), a general system that accompanies the protocol and establishes the levels of CO₂ emissions permitted in each country in line with its targets, expressed in AAUs ("Assigned Amount Units"). 1 AAU = 1 tonne of CO₂ equivalent (a generic unit which enables comparisons to be drawn between the six gases). These units can be traded between countries or between companies which fall short of or exceed their emission limits at the end of each year. Emissions can also be traded in Certified Emission Reductions (CERs, used in the Clean Development Mechanism), Emission Reduction Units (ERUs, used in Joint Implementation) and EMUs (used in reforestation projects).

- The Clean Development Mechanism (CDM)

Under this mechanism companies or governments from Annex I countries undertake emission reduction projects in non-Annex I countries, i.e. in developing countries, to enable the latter to achieve additional GHG reductions. These projects are usually concerned with energy efficiency, fostering the use of renewables or encouraging sustainable transport. The additional reductions achieved can then be traded on the market.

- Joint Implementation.

This is similar to the CDM, but refers to projects in the industrialised countries listed in Annex B.

As explained in Section 4 above, the possibility of trading in emission rights means that in a context of efficient allocation CO₂ can be reduced in those sectors and areas where it is most cost efficient to do so.

Implementing policies of this type is extremely complex, so the regulatory framework has had to be discussed and developed subsequently at various Conferences of Parties (CoPs). These conferences are held annually to monitor progress in commitments and undertake new challenges.

Apart from the CoPs (which are the “supreme body” of the UNFCCC), the world-wide negotiation process includes conferences of parties serving as the meeting of the Parties to the Kyoto Protocol (CMPs, which are the “supreme body” of the Protocol) and meetings of the subsidiary bodies¹¹ which monitor the technical workings of the system.

For the Kyoto Protocol to be implemented it had to be ratified by at least 55 countries representing at least 55% of all emissions. This figure was achieved when Russia decided to sign up, and the Protocol eventually came into force on February 16, 2005. Its subsequent ratification by Australia in 2007 provided a further substantial boost.

At CoP 12, held in Nairobi in 2006, a commitment was made to approve a new protocol for the post-Kyoto period at CoP 15, which is scheduled to take place in Copenhagen in 2009.

CoP 13 in Bali in 2007 set out a path for the culmination in 2009 of negotiations on the post-Kyoto period, approved the launch of the Adaptation Fund, promoted measures for the effective transfer of technology to developing countries and specified policies for reducing emissions due to deforestation. The most recent Conference (CoP 14 in Poznan) reiterated the commitment to approve a new protocol at the 2009 Conference in Copenhagen (CoP 15).

The developed countries are hoping that the developing countries, especially those with the fastest-growing economies (China, Brazil and India), will commit to achieving significant reductions, while the latter in turn are hoping for major commitments from the developed countries in emission reductions and in providing them with financial, political and technological support in reaching their targets.

The undertakings given by new US President Barack Obama and the triumph of the view that climate change is not a zero sum game but rather requires that forward-looking, co-operative geopolitical strategies be worked out mean that some hope can be held out in regard to the results expected from the Copenhagen Conference (paraphrasing Santarius *op cit*).

The issues examined above illustrate how hard it is to reach clear international agreements on matters as complex as climate change.

5.2 The Role of the IPCC

In terms of policy action, it should be recognised that the IPCC has played a vital role in promoting the gathering of all the necessary scientific knowledge and the use of the evidence gathered for policy making, by organising detailed assessments of all the scientific, technical and socio-economic aspects of climate change by leading scientists around the world.

The IPCC has effectively contributed to the use of “science for policy making” and to the mainstreaming of the science of climate change, which has allowed policy makers to adopt ambitious

¹¹ The Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI).

policies to combat climate change. The Norwegian Nobel Committee recognised these efforts “to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change” in awarding the IPCC the Nobel Peace Prize for 2007 (shared with former US Vice-President Al Gore).

The IPCC’s main assessment reports were published in 1990, 1995, 2001 and 2007. Each report is divided into three main chapters, referred to as Working Groups I (The Physical Science Basis), II (Impacts, Adaptation and Vulnerability) and III (Mitigation of Climate Change). As an illustration of just how ambitious this task is, note that the 4th Assessment Report involved over 6 years of contributions from more than 2500 expert scientific reviewers, more than 800 contributing authors and more than 450 lead authors from 130 countries.

Thanks to these reports there is now a clear consensus regarding the following aspects:

- Over the last century the Earth’s climate has changed.
- Most global warming is the result of human activity.
- Temperatures will continue rising over the 21st century.
- There will be many impacts but they cannot be predicted at regional scale.
- The greater the emissions the more global warming there will be.
- The greater and faster the warming the greater and more severe the effects will be.
- The more global warming there is the more irreversible the process will become.

Science has also established that the main challenge is to stabilise the stock of greenhouse gases at between 500 and 550 parts per million (ppm), which will result in a temperature increase of 2°C. Taking into account that the current level is 430 ppm and that before the Industrial Revolution the level was 280 ppm, the immensity of the challenge is clear. Policies should thus be designed with a view to succeeding in this effort using all available policy instruments and offsetting costs and benefits. All countries at all levels of governance have a duty to contribute to the struggle against climate change.

Other pieces of research such as the Stern Report have contributed to our understanding that the cost of failing to act may be five times higher than the investment necessary for effective, global action. The Stern Report estimates “the annual costs of stabilisation at 500-550ppm CO₂e to be around 1% of GDP by 2050” while “climate change will reduce welfare by an amount equivalent to a reduction in consumption per head of between 5 and 20%” (Stern, 2006).

These conclusions have filtered through to the population, companies, institutions, NGOs, etc., and have helped establish a common understanding that the fight against climate change is one of the biggest challenges that humanity faces in this century.

But what knowledge communities have contributed to this? What mechanisms have been crucial in acting as a catalyst for paradigm shifts?

We believe that all this transfer of knowledge has been possible thanks to the “confidence” generated by the way in which the IPCC reports have been produced. We all know that the reports are based on meta-analyses undertaken by researchers who have taken into account only those conclusions that have sound foundations and are backed by good research.

Although it has taken longer than predicted, governments have been also able to convey the relevant empirical findings to the relevant institutions and to all interested parties in the community.

Almost everyone knows that we must change our pattern of behaviour if we are to overcome climate change, that the energy model adopted is crucial, that fossil fuels must be replaced by other sources of energy – mainly renewable energy – and that if we are to do our duty to future generations we cannot continue living according to our present habits. We are aware that transport is a major contributor to the problem of CO₂ emissions, that we need to travel by public transport rather than private cars, that governments need to continue with policies for managing the demand for transport and that rail transport is an alternative that will be developed to a large extent before long.

All this knowledge has been and is still being transferred to individuals in developed countries, increasing their awareness of the problems that climate change will cause.

There is also a knowledge community which understands that climate change is a global problem and as such needs global solutions, though that does not imply that local actions are not necessary. The globality of the problem means that there is a need for co-ordination and co-operation between the countries of the world, albeit in a way that admits the possibility of different responses, because not all countries are in the same position in terms of income and wealth. and they are therefore not all capable of undertaking the same efforts to mitigate emissions.

6. Climate Change as a Challenge and an Opportunity

Human capital brings a new dimension to the traditional concept of economic growth and development as dealt with by economists. This is not a new conclusion, but it is significant if we are to understand the role that the protection of our environment and our natural resources may (and should) play in the new concept of welfare.

A subgroup of individuals gathered in a knowledge community provide fertile ground for the acceleration of learning processes which can thus help create not just internal effects (for individuals and for their surroundings) but also external effects for the community as a whole. Those external effects may even extend beyond national borders.

In this sense, this paper seeks to illustrate why climate change is a good example of this process, or in other words why the theories of Becker and Lucas are certainly valid in explaining the process of creation and globalisation of knowledge that is taking place in the field of climate change. The establishment of the IPCC by the UN in 1988 with the remit of reviewing all existing scientific knowledge and drawing up rigorous reports on the state of knowledge and its repercussions for the quality of human life has been a determinant factor in this process. There can now be no doubt that climate change exists, or that its main cause is probably the burning of fossil fuels as part of human activity.

The existence of what we have called “sophisticated consumers” helps explain the underlying reasons for encouraging the complex technological and political alternatives that exist to combat this global problem.

From the viewpoint of an economist, climate change can be modelled as a global, perfectly mixed “public bad” (as opposed to the concept of a “public good”, which in this case means the atmosphere). As a result, no-one can be excluded from its effects (or from the consumption of the resource of “air” or

“atmosphere” in the public good), and it will always be over-supplied if the market is allowed to act unhindered, i.e. if there is no public-sector intervention.

This characterisation reveals how tremendously difficult it is to design and implement a public-sector policy that results in an appropriate allocation. The difficulties include the large number of actions required to tackle climate change, the need to find a global solution, the complexity of sharing out the costs and benefits of the policies implemented and their interaction with other policies. The uncertainty that still surrounds estimates of the effects and consequences of climate change and the highly long-term nature of the problem also clearly hinder actions by planners.

We have sought to highlight the market-based mechanisms which currently top the list of policy instruments in use for tackling the problem: emissions trading, subsidies and taxation. The examples given show that they can be cost-efficient and can all achieve the same results in terms of mitigating emissions, but that the consequences as regards the distribution of burdens may be very different.

The design of the instruments to be used is therefore crucially important in achieving policies that are effective and take into account such concepts as intergenerational, international and intra-generational equity.

Finally, we have sought to illustrate the debate by providing further information on the international context and design of climate policy in the framework of the United Nations, highlighting the role of the IPCC as a driver and prescriber in globalising and disseminating knowledge to solve the problem. The IPCC has helped to analyse, bring together, sum up and above all spread existing scientific knowledge and instill a realisation of the seriousness of the situation by getting its message through to the community of policy makers and the general public. The contribution of the Stern Report must also be noted.

Climate change is probably the biggest challenge facing humanity, in view of the global nature of the problem and, especially, the seriousness of its potential impacts. If the most pessimistic scenarios forecast by scientists come true then the very inhabitability of our planet and therefore our own survival are at risk. The magnitude of the challenge contrasts with the great opportunity that it may provide to bring about a paradigm shift and begin to redefine society and our way of life towards models that are more in balance with and fairer to present and future generations.

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