Macro Policies For Climate Change: Free Market Or State Intervention?

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Abstract

The central issue studied in this essay is the meaning and implications for public policy of Nicholas Stern's statement that "Climate change is the greatest and widest-ranging *market failure* ever seen" (Stern, 2006).

To deal with this issue we analyze the two big currents about public policy measures in general: market oriented and state intervention. We also present the current conceptual framework for debating public policy for analyzing the policies recommended and applied so far, to deal with Climate Change's causes and effects, from an economic perspective. We present the main arguments of the Stern Review. Finally we get into the debate between Stern and Nordhaus. Our conclusion is that there is a need for *strong state intervention* to make the climate change mitigation policies to reach the desired effects.

Keywords: market failure, public policy, climate change, welfare.

JEL: H23 Q54, Q58

Introduction

On July 2005, in the United Kingdom an independent Review was commissioned, by the Chancellor of the Exchequer, reporting to both the Chancellor and to the Prime Minister, as a contribution to assessing the evidence and building understanding of the economics of climate change. The Review was commissioned to Nicholas Stern. The Review examined the evidence on the economic impacts of climate change itself, and explored the economics of stabilizing greenhouse gases in the atmosphere (Stern, 2006, 2007).

Stern states in the summary that: "Climate change presents a unique challenge for economics: it is the greatest and widest-ranging *market failure* ever seen" (Stern, 2006). What did Stern mean by this statement and what were its implications for public policy regarding climate change?

This is the main question we are addressing in this essay. For that purpose, in the first section we briefly analyze the two big currents about public policy measures in general: market oriented or state intervention and we present the current conceptual framework for debating public policy. In the second section, we analyze the policies recommended and applied so far, to deal with Climate Change's causes and effects, from an economic perspective. In the third section, the main findings of Stern Review are presented. The fourth section deals with the Nordhaus versus Stern debate. Finally, some conclusions are drawn.

I. The political Economy debate: free market *versus* state intervention

There has always been in Political Economy a paradigmatic division among those who favor state intervention in designing and applying economic policy (the interventionists) and those who do not favor the state intervention in the economy at all (the liberals). The debate, as old as the capitalist economy itself, has involved all types of issues. Some of these issues are purely ideological, some are theoretical, but all involve the design and implementation of public policies aimed to improving the economic well-being of the population, to fostering economic development and/or to preventing economic crises.

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The state intervention argument has its origin in the early stage of capitalism in England, commercial capitalism, whose theorists, like Misselden and Mun, defended protectionist policies and monopoly's concessions granted by the state, in the sixteenth and seventeenth centuries. All of this was strongly opposed by the liberals Petty, Locke, North, Law, Hume and Smith, in the seventeenth and eighteenth centuries, who favored free trade and no state intervention in the economy (see Schumpeter, 1966, and Roll, 1974). The debate was apparently won by the liberals whose theories dominated the economic thinking at the time. In practice, however, during the nineteenth century except for Britain, not one of today developed European countries, or the United States, followed free trade policies but, quite the contrary, all of their governments protected their local industries against foreign competition as a strategy for development, leaded by the state (see Chang, 2002).

The debate was reopened in the twentieth century mostly due to the 1930s deep crisis of the US economy and, in particular, the remedies followed for recovering. So, in the second a quarter of the past century the debate was leaded, on the interventionist side by the British John M., Keynes, and on the liberal side by the Austrian Friedrich A., von Hayek (see Foley, 2006). There was a period in which Keynesianism seemed to prevail. But in the last fifty years Neoclassical thinking, labeled also as *neoliberal* has been predominant within the so called *Mainstream Economics* – the accepted paradigm in Economics – both in theory, that is, teaching, and in practice, that is, policy, in most capitalist countries. So much so, that Keynes' analysis was adopted by Samuelson and Hicks, both prominent neoclassicals, as a constituent part of accepted theory (mainstream economics) in what Joan Robinson defined as "Bastard Keynesianism" (Robinson, 1962).

Most recently the protection of the environment has been one of the issues under debate between these two main currents (interventionist and liberals). There have been those who favor state intervention on environmental matters from an extreme called *nationalized delivery* of environmental protection, and those who rely on the free market mechanism (Adam Smith's *Invisible Hand*) to self-regulating the, potentially dangerous to the environment, activities. There has been, of course, also a wide space for a variety of policies in between the two extremes (see Hepburn, 2010, pp.121-122). Hepburn says that unlike many areas of economic activity, for the environment relying on the free market is highly unlikely to deliver satisfactory outcomes because firms have inadequate incentives to internalize externalities without government intervention. On the other extreme, state provision is said to entail a great politicization of operational decisions (and hence a low economic efficiency) and may require a great deal of information which is often unavailable. So, he says the impossibility of a free market approach and the inefficiency of nationalized delivery, imply a role for government in the middle of the spectrum (Hepburn, 2010).

The conceptual framework of the debate has been based on the neoclassical Utility theory at social level, *i.e.*, modern Welfare Economics, developed since the late thirties by, among others, Bergson (1938), Arrow (1951) and Debreu (1954). A crucial aspect of this theory, *i.e.* the interpersonal comparisons of utility, was challenged by Nicholas Kaldor (1938) and defended by Lionel Robbins (1938), with a no definitive result.

Within this conceptual framework a *market failure* is a situation where in the allocation of resources by a free market is not efficient. That is, there exists another conceivable outcome where a market participant may be made better-off without making someone else worse-off. A market failure can be viewed as a scenario where individuals' pursuit of pure self-interest leads to an outcome that is not Pareto efficient. An economic system that is not Pareto efficient implies that a certain change in allocation of goods may result in some individuals being made "better off" with no individual being made worse off, and therefore can be made more Pareto efficient through a Pareto improvement. Here "better off" is interpreted as "put in a preferred position." It is commonly accepted that outcomes that are not Pareto efficient are to be avoided, and therefore Pareto efficiency becomes an important criterion for evaluating economic systems and public policies. If a market failure exists, mainstream – both neoclassical and Keynesian – economists believe that it may be possible for a government to improve the inefficient market outcome, while several heterodox schools of thought disagree with this.

Different economists have different views about what events are the sources of a market failure. Joseph Stiglitz points out that, early discussions of market failure, like the one of Bator (1958) focused on

externalities, natural monopolies, and public goods. Later discussions focused on problems of incomplete markets, imperfect information, and the pervasiveness of imperfect competition (Stiglitz, 1991) all of which are analyzed by Stiglitz himself.

But what about unequal income distribution as resulting of free market operation, is it a market failure? Stiglitz says that, according to the second fundamental theorem of welfare economics, we can separate out issues of economic efficiency from issues of equity. But as it turns out, in his analysis of the second theorem and some cases of imperfect markets, we cannot (Stiglitz, 1991, p. 28 and p. 30).

Stiglitz finds that since the mid-60s, there has been "a closer examination of Adam Smith's invisible hand. The theoretical research has taken two different strands (reflecting two ideological strands within the profession). The first has attempted to show that the economy is Pareto efficient under much more general conditions than those originally used by Arrow and Debreu. The second has attempted to show that there were assumptions in Arrow and Debreu's analysis which, while perhaps mentioned, did not receive the attention they deserved. These assumptions make the theorems [of welfare] of limited relevance to modern industrial economies. In this view, Adam Smith's invisible hand may be invisible because, like the Emperor's new clothes, it simply isn't there; or if it is there, it is too palsied to be relied upon" (Stiglitz, 1991, p.5). The two schools are thus defined as Microeconomics and Macroeconomics, and the crucial discrepancy between them is related to the explanation of unemployment in capitalist economies, while for the first it is a temporary and not significant phenomenon, for the second it is endemic to the capitalist system and shows the irrelevance of welfare economics and perfect competition theorems (Stiglitz, 1991, p.7).

To these, another source of market failure has been added: the question of incentives or principal-agent problems. The Theory of Incentives or Principal-agent models (Laffont and Martimort, 2002) is the most recent development within the neoclassical anti-interventionist approach, according to Chang (2003, p. 27). In his opinion these models are usually presented as neutral efficiency arguments but have much deeper political impacts.

The Principal-Agent approach has inspired market oriented environmental policies for various areas of concern (see for example, Franckx and D'Amato, 2009; Szatzschneider and Kwiatkowska, 2008). In the case of Climate Change mitigation policies, the Principal - Agent theory is at the base of the "Carbon markets" policy, aimed mainly to incentive producers, which are high GHG emitters, to switch from high carbon technologies to low carbon technologies, *i.e.* the so called "Cap-and-Trade" policy. The model is also oriented to consumers (see Schatzki T. and R.N. Stavins, 2012). In either case, it has very strong limitations in practice (see Ackerman, 2008). But also in theory, it is well known the "Principal-Agent problem".[2] Stiglitz shows that all principal-agent problems are not Pareto efficient, therefore, they are market failures as well (Stiglitz, 1991, p. 30).

In sum, we may say that the basic criterion to define what is, and what is not, a *market failure* depends entirely on considerations of efficiency as defined by modern welfare economics, completely dominated by neoclassical thinking. However, in practice there has been some room for the application of protectionist (non-efficient) policies or other interventionists (*i.e.* non-free market) measures, considered as *second-best* policies, when the first-best policy is "regarded as politically or institutionally impossible" (Kindleberger, 1973, p.200). If *free market*, as an institution, is not working, then there is a market failure, and so it is justified the use of interventionist measures, as a second best policy, even within the neoclassical tradition.

[2] Principal-agent problem is a particular game-theoretic description of a situation. There is a player called a principal, and one or more other players called agents with utility functions that are in some sense different from the principal's. The principal can act more effectively through the agents than directly, and must construct incentive schemes to get them to behave at least partly according to the principal's interests. The principal-agent problem is that of designing the incentive scheme. The actions of the agents may not be observable so it is not usually sufficient for the principal just to condition payment on the actions of the agents. http://economics.about.com/od/economicsglossary/g/principalag.htm.

II. The environment as subject of public policy

Widespread social awareness about the environment being endangered by pollution, produced by human activities, started in the sixties. This was mainly due to scientific discoveries about the occurrence of this phenomenon and its magnitude, affecting various natural habitats of animal and plants, all over the world. However, pollution was seen then as a local, *i.e.* national, or a regional, problem, concerning therefore local governments to deal with it or reaching regional agreements to the same purpose. Moreover, since stopping or preventing pollution implied reducing the levels of production and consumption in the short run, affecting in principle the economy of a given country and its population, it was a matter seen as concerning first the national producers and consumers and, therefore, national authorities, that is, the *state*, as the representative of the nation.

Accordingly public policies aimed to reduce or eliminate pollution were carried out by the state through the usual means of state intervention in the economy, *i.e.*, fixation of rules and standards for pollution activities, like time or space limits, technology improvements, and various types of economic and or legal sanctions against violators of these rules; taxes were also included and even prohibitions in the use or production of polluting substances, or their free disposal to the air, water or land.

Still, one of the main contributors to earth pollution (rivers, seas, lands and, specially, air), which is *oil*, could not be banned, neither in its production, nor in its use as the main fuel for industrial activities in and for consumption. In other words, all economies in the world depended, one way or another, on oil fuels and alternative technologies were not technically or economically feasible in most countries. A few countries, however, developed nuclear facilities for non-military purposes, looking for the substitution of fuel power by nuclear power, mainly to produce electricity.

Everything changed in the eighties in Environmental Economics. On the one hand, there was a boom in world trade in goods and capitals, as a result of the opening of many local and regional markets previously closed by protectionist practices, which was baptized as *globalization*. It showed the actual predominance of *Neoliberalism* inspiring free market economic policies in most developed countries and in many developing ones as well. On the other, there was the scientific confirmation of an old hypothesis regarding a great environmental phenomenon, this one affecting the whole planet: Global Warming.

II.i Neoliberalism of the eighties

Hepburn says that during the 1970s the state kept on growing in many developed countries as a result of the Keynesian public programs and policies tendencies from the past, but the revival of monetarist theory began to provide growing intellectual opposition to increasing enlargement and more important growth faltered in the 1970's with the oil shocks and the collapse of the Bretton Woods system. These conditions ushered Margaret Thatcher into power in the UK, in 1979, and Ronald Regan in the US, in 1980, with a corresponding change in political philosophy. In due course this would also change the environmental policy with the creation of "environmental markets" (Hepburn, 2010).

Global warming and climate change

In 1985 a joint the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) Conference on the "Assessment of the Role of Carbon Dioxide and Other Greenhouse Gases in Climate Variations and Associated Impacts" assessed the role of carbon dioxide and aerosols in the atmosphere, and concluded that greenhouse gases "are expected" to cause significant warming in the next century and that some warming was inevitable (WMO, 1986). In June 1988, James E. Hansen made one of the first assessments that human-caused warming had already measurably affected global climate (Hansen, 1988).

Accordingly, the Intergovernmental Panel on Climate Change (IPCC) was created in 1988, under the United Nations and the World Meteorological Organization. Since then, the IPCC has tried to induce state and public policies' options for adaptation and mitigation of Climate Change (IPCC, 2011). And given that Climate change is a global phenomenon in its causes and in its effects, it required a political platform

among countries to cope with it. So, the IPCC played a decisive role in the creation of the United Nations Framework Convention on Climate Change (UNFCCC) in 1990, and the adoption of the Kyoto Protocol in 1997.

II.ii Policy recommendations of the IPCC and the OECD

The measures originally suggested by IPCC for adaptation and mitigation of Climate Change were grouped into five categories: market based programs; regulatory measures; voluntary agreements; scientific research and development (R&D); and infrastructural measures. The IPCC clearly warned that: "No single measure will be sufficient for the timely development, adoption and diffusion of the mitigation options. Rather, a combination of measures adapted to national, regional and local conditions will be required" (IPCC, 1996).

Five years later, the 2001 IPCC Report on Mitigation pointed out that, important considerations in the analysis of climate change mitigation options are, differences in the distribution of technological, natural and financial resources among and within nations and regions, and between generations, as well as differences in mitigation costs. And – it said – there is also an important issue of *equity*, namely the extent to which the impacts of climate change or mitigation policies create or exacerbate inequities both within and across nations and regions. It said too that the various estimates of cost and benefits of mitigation actions differ because of how welfare is measured, the scope and methodology of the analysis, and the underlying assumptions built into the analysis. As a result, it says, estimated costs and benefits may not reflect the actual costs and benefits of implementing mitigation actions (IPCC, 2001). With respect to mitigation policies the report recommended that "national responses to climate change can be more effective if deployed as a portfolio of policy instruments to limit or reduce greenhouse gas emissions…[which]... may include emissions-carbon-energy taxes, tradable or non-tradable permits, provision and/or removal of subsidies, deposit-refund systems, technology or performance standards, energy mix requirements, product bans, voluntary agreements, government spending and investment, and support for research and development." Some report's findings on this matter are that "Energy efficiency standards and performance regulations are widely used, and may be effective in many countries, and sometimes precede market based instruments. Voluntary agreements have been used more frequently, sometimes preceding the introduction of more stringent measures. Information campaigns, environmental labeling, and green marketing, alone or in combination with incentive subsidies, are increasingly emphasized to inform and shape consumer or producer behavior" (IPCC, 2001).

In these reports the need for state intervention arises also from the existence of *market imperfections* in each and every economy in the world. The OECD emphasizes that putting a price on GHG emissions, through price mechanisms, has the limitation that "they do not address the full range of *market imperfections* that prevent emissions to be cut at least cost, such as information problems" (Duval, 2008).

The OECD finds also that empirical analysis indicates that the most important determinant of innovation in the area of renewable energy technologies is general innovative capacity. However – the OECD study says – in the case of energy "public policy makes a difference. Public R&D expenditures on renewable energies induce innovation, as do targeted measures such as renewable energy certificates and feed-in tariffs" (Haščič, et al., 2010).

Finally, another issue that calls for state action is the "issue of equity, namely the extent to which the impacts of climate change or mitigation policies create or exacerbate inequities both within and across nations and regions". This implies the need for the application of state policy measures aiming to prevent or to compensate any inequities that may result from either climate change impacts or mitigation policies, between sectors or population groups within a country, and internationally agreed regulations in the same direction for inequities between countries.

Despite all recommendations, market oriented policies prevailed in most countries and they did help, but little, in solving the GHG emissions problem. So, Nicholas Stern pointed out in his Review in 2006, after eighteen years of the IPCC foundation, that Climate Change was "…the greatest and widest-ranging *market failure* ever seen" (Stern, 2006). Stern also called for a "major change" (as opposed to a marginal one) in GHG reductions.

Now, we can interpret more clearly what he meant by "market failure". In the first place this is a situation – as defined above – in which free market yields an outcome which is not Pareto efficient. The reasons for that may be, as IPCC and OECD pointed out the existence of market imperfections in most countries; that we are dealing with a negative externality that cannot be internalized by firms without government intervention, according to Hepburn's opinion; that pollution is a public good, or rather a *public bad*, and therefore its price cannot be determined by free market forces; that it is a case of *imperfect information* as the OECD pointed out (Duval, 2008); or finally as Hepburn based on Stiglitz considers, that this a market failure due to principal-agent problems (Hepburn, 2010: Stiglitz, 1991). For all these reasons, there seems to be no doubt that Climate Change is a great market failure, even within the neoclassical welfare economics analysis framework. But there is also another cause of market failure that applies in this case, the question of *equity*, emphasized by IPCC and OECD, whether or not this cause is considered a valid one in modern welfare economics.

Therefore this great market failure calls for *state intervention*, even as a second best policy, that is, with full awareness that it is not possible to have a Pareto efficient solution, in modern welfare economics terms. And this state intervention has to be as large as the size of the problem to be solved, in order to produce the *major change* it is required, as Stern stated.

According to Hepburn (2010 p.121-122): "The degree of state involvement in delivering social outcomes (such as environmental protection) might be considered to be on a spectrum running from 'free market' at one end, to 'nationalized delivery' at the other end:

- Free market: no government involvement; individuals and firms voluntarily acquire information on externalities and voluntarily and altruistically internalize those externalities;

- Information provision: government assumes the role of aggregating and disseminating information about externalities and their shadow prices, but does nothing more;

- Moral suasion: government provides information and may even seek to persuade people and firms to change their preferences and objectives. In its best form, this might constitute a form of 'government by discussion';

- Economy-wide relative prices: government determines the appropriate price or quantity of the social good or externality (e.g. carbon dioxide CO_2) emissions, SO_2 emissions, water effluent, biodiversity) and implements policy to correct relative prices (e.g. economy-wide taxes, trading schemes, etc.);

- Output-based intervention: government specifies output standards for specific sectors or firms (e.g. CO_2/MW standards), but does not require the use of any particular method to deliver those standards;

- Input – or technology – based intervention: government specifies or encourages or requires firms to employ particular technologies or inputs (e.g. SO2 scrubbers), either through explicit regulation or through taxes or subsidies;

- Project-level intervention: government specifies or encourages particular projects to occur, through subsidy or other financial (e.g. balance sheet) support (e.g. EU carbon capture and storage (CCS) program);

- State capitalism: state-owned enterprises follow guidance given by their (government) shareholder; some flexibility for implementation may be retained if targets are expressed and political incentives put in place, but often executives are given direct instructions;

- Nationalized delivery: government finances and delivers on environmental protection directly through central government departments".

These types of policy measures with the exception of the first three require some degree of state intervention. The first four – mostly market oriented – are the most popular and have been tried even together in various countries aiming to the same target: reducing GHG emissions, but the results so far have not been fully satisfactory. While GHG emissions have been effectively reduced in some countries, they have not in others and the global level of emissions keeps growing dangerously. As Stern himself pointed out, Climate Change is a "Global" problem and requires "Global" measures to face it, that is, general agreements among all countries (involving especially those which are the higher GHG emitters) applying the same policy measures to reduce emissions.

II.iii Policies results 1990-2010

Table 1 shows that most parties in the so called 42 parties of Annex I of the United Nations Framework Convention on Climate Change (UNFCCC), with the exception of the United States, have reduced to some extent their GHG emissions (mostly motivated by the Kyoto Protocol signed in 1997) which implied the use of some sort of state enforced *regulations*, which, according to Nordhaus (2007b), represents the alternative (inefficient) policy to his most favored market oriented policy, *i.e.*, carbon taxes, in this case called harmonized carbon tax (HCT) policy, using only the price mechanism to reduce GHG emissions.

Table 1

GREENHOUSE GAS (GHG) EMISSIONS

Selected years in Gg CO_2 equivalent

	1990	1994	1995	1996	2000	2005	2009	2010	2011	Per cent variation 2010/1990
All countries	***22,467,709***	***22,977,422***	***23,461,466***	***23,989,514***	***24,807,255***	***29,677,031***	***32,049,580***	***33,615,389***		49.6
Annex I countries (41)	17,693,629	15,843,405	16,073,274	16,032,741	16,061,700	16,148,996	14,762,870	15,418,893	15,283,847	-12.9
United States	5,388,746	5,643,490	5,758,850	5,948,157	6,394,662	6,197,432	5,545,717	5,747,137	5,797,284	6.7
European Union (27)	5,319,540	4,869,349	4,917,672	5,018,831	4,786,211	4,855,690	4,268,118	4,409,255	4,260,129	-17.1
Russian Federation	3,436,458	2,106,483	1,979,703	1,844,650	1,589,110	1,588,217	1,460,346	1,555,159	1,692,400	-54.7
Japan	1,197,139	1,279,818	1,257,133	1,266,427	1,256,110	1,262,579	1,132,759	1,181,609	1,232,294	-1.3
Non Annex I countries	4,774,080	7,134,017	7,388,192	7,956,773	8,745,555	13,528,035	17,286,710	18,196,496		281.2
China	n.d.	3,650,138	n.d.	n.d.	n.d.	7,045,045	n.d.	*7,834,014*	n.d.	
India	n.d.	1,228,540	n.d.	n.d.	1,301,204	n.d.	n.d.	*1,899,040*	n.d.	
Other countries	n.d.	2,255,339	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	

Sources: Elaborated with data from UNFCCC Data Interface except for data in italics taken from Tom Boden and Bob Andres, Carbon Dioxide Information Analysis Center Oak Ridge National Laboratory and Gregg Marland, Research Institute for Environment, Energy and Economics Appalachian State University.

Given these tendencies the OECD projected the scenario for 2050 shown in Figure 1 below, where it is clear that the only mitigation policy working simultaneously all over the world is that of increasing CO_2 sinks, which means reducing and recovering deforestation.

It must be noted that figures for total GHG emissions for the year 2010 do not coincide with those from UNFCCC due to various methodological differences. However, the important question is that most mitigation policies applied in some countries have a reduced effect in the overall GHG emissions tendencies, mainly due to those countries which are not regulating enough their emissions or not regulating at all, and they happen to be the most important GHG emissions producers.

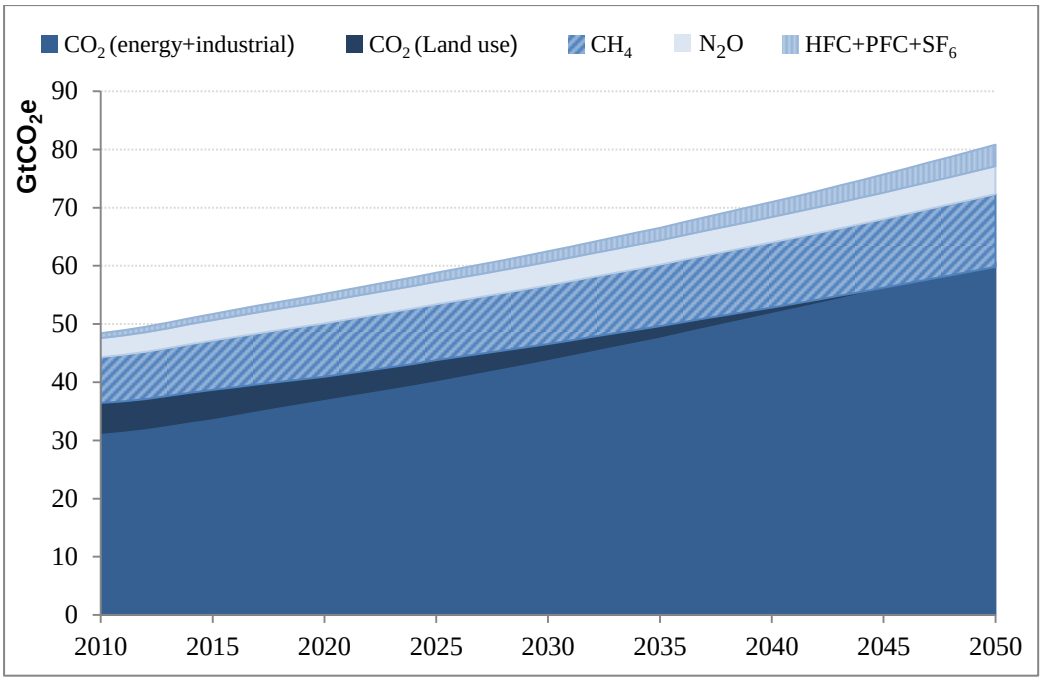

Figure 1 GHG emissions: *Baseline,* 2010-2050 Panel by gases
Source: OECD Environmental Outlook Baseline

III. The Stern Review

The Stern Review (2006) was published sixteen years after the *IPCC First Assessment Report* (1990) and ten years after the *IPCC Technical Report* (1996).

From the very beginning Stern makes a very strong statement: "The scientific evidence is now overwhelming, climate change presents very serious global risks, and it demands an urgent global response". Almost immediately Stern introduces the famous paragraph: "Climate change presents a unique challenge for economics: it is the greatest and widest-ranging market failure ever seen. The economic analysis must, therefore, be global, deal with long time horizons, have the economics of risk and uncertainty at center stage, and examine the possibility of major, non-marginal change".

The Stern Review consists basically of three assessments: (1) an analysis of the GHG emissions tendencies and their effects on climate change in particular, the increase of earth's mean temperature (global warming); (2) an estimation of the probable impacts (mostly negative) of this global warming on economic and social life, all over the world, in monetary terms, including non-market damages and, (3) a series of recommendations for policy measures aimed directly to reduce GHG emissions, in order to stabilize CO_2 concentrations in the atmosphere, before a critical level is reached.

III.i GHG emissions under "business as usual" (BAU)

At the time of the Stern Review, the level of GHG concentration in the atmosphere was estimated of around 430 parts per million (ppm), CO_2 equivalent, compared with 280ppm before the Industrial Revolution, *i.e.*, 1750-1850. Given the estimated annual rate of GHG emissions flow for 2005, the first prediction of the Stern Review was that if this flow of emissions would not increase at a higher rate than this, the concentration of GHG in the atmosphere would reach *double* pre-industrial levels by 2050 (550ppm CO_2 eq.). But, the annual flow of GHG emissions was already accelerating, so the level of 550ppm CO_2 eq. could be reached earlier, by 2035. At this level the Review says there is *at least* a 77 per cent chance of a global average temperature rise *exceeding* 2°C. And under a "business as usual" (BAU) scenario the stock of GHG could *more than triple* by 2100, with at least a 50 per cent risk of exceeding 5°C global average temperature change during

the following decades. “This would – the Review warns – take humans into *unknown territory*” (Stern, 2006, pp. iv and 158).

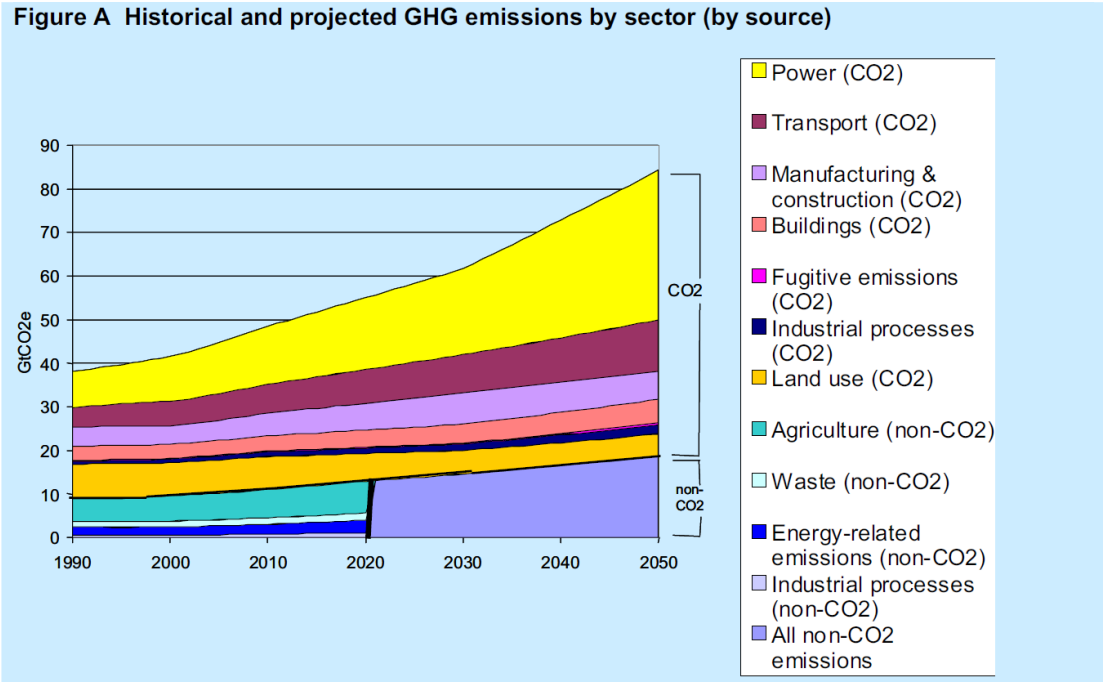

Figure 2
Source: Stern Review: The Economics of Climate Change, p. 173.

III.ii Climate change damages and costs

The Review considers three approaches for estimating the costs of climate change:

Estimating physical impacts on economic activity, on human life and on the environment
The Stern prediction based on scientific models is that under a BAU scenario, average global temperatures will rise by 2-3°C within the next fifty years. But if GHG emissions continue to grow the Earth will be subject to several degrees more warming. However, this predicted situation will not be the same for all countries, since the impacts of climate change are not evenly distributed, that is, the poorest countries will be the most affected and the earliest. On the other hand, while climate change may have small positive effects for a few developed countries in the beginning, it is likely to be very damaging for higher temperature increases. The *costs* of extreme weather alone could reach 0.5 to 1 per cent of world GDP per year by 2050, and will keep rising if the world continues to warm.

***Estimating monetary aggregates of costs and risks with the use of* IAMs**
This approach implies the use of Integrated Assessment Models (IAMs) that produce aggregate monetary estimates of costs. Again a strong statement by Stern was: “The monetary impacts of climate change are now expected to be more serious than many earlier studies suggested, not least because those studies tended to exclude some of the most uncertain but potentially most damaging impacts” (Stern, 2006, p. viii).

Stern argues that formal IAMs in the past used as a starting point a scenario of 2 to 3°C warming and in this temperature range the cost of climate change could be equivalent to a permanent average loss of 0 to 3 per cent in global world output. But, given the uneven distribution of damages, developing countries will suffer even higher costs. However – he says – more recent evidence indicates that temperature changes resulting from BAU trends in GHG emissions may exceed 2–3°C by the end of this century. And, this increases the likelihood of a wider range of impacts than previously considered. Moreover, many of these

impacts are more difficult to quantify. With 5-6°C warming, existing models that include the risk of abrupt and large-scale climate change estimate an average of 5-10 per cent loss in global GDP, with poor countries suffering costs above 10 per cent of GDP.

The Review uses one particular model PAGE 2002 – that includes the possibility to analyze risks explicitly – in order to analyze the response of these models to updated scientific evidence on the probabilities attached to degrees of temperature rise. Besides the using of the model with one set of data consistent with the climate predictions of the 2001 IPCC Report, it was also utilized with another set of data that includes a small increase in the amplifying feedbacks in the climate system. The model also considered "how the application of appropriate discount rates, assumptions about the equity weighting attached to the valuation of impacts in poor countries, and estimates of the impacts on mortality and the environment would increase the estimated economic costs of climate change"[3] (Stern, 2006, p. ix). The Stern's model estimated the total cost over the next two centuries of climate change associated under BAU, GHG emissions of an equivalent to an average reduction in global per-capita consumption of at least 5 per cent.

But – Stern goes on – the cost of climate change impacts under a BAU path would increase still further, if the model takes into account three important factors: (1) including direct impacts on the environment and human health (called 'non-market' impacts), increases the total cost of climate change from 5 per cent to 11 per cent of global per-capita consumption; (2) recent scientific evidence indicates that the climate system may be more responsive to GHG emissions than previously thought, because of the existence of amplifying feedbacks. Stern estimates that the potential scale of the climate response could increase the cost of climate change on the BAU path from 5 to 7 per cent of global consumption, or from 11 to 14 per cent, if the non-market impacts are included; (3) a disproportionate share of the climate-change burden falls on poor regions of the world; when this unequal burden is weighted appropriately, the estimated global cost of climate change at 5-6°C warming could be more than 25 per cent higher than without such weights.

So, putting these additional factors together would increase the total cost of BAU climate change to the equivalent of around a 20 per cent reduction in consumption per head, now and into the future. In sum, analyses that take into account the full ranges of both impacts and possible outcomes suggest that BAU climate change will reduce welfare by an amount equivalent to a reduction in consumption per head of between 5 and 20 per cent.

Comparing costs and benefits of action

This approach compares estimates of the changes in the expected benefits and costs over time from a little extra reduction in emissions, and avoids large-scale formal economic models.

According to the Review calculations, the social cost of carbon, on a BAU trajectory, was about $85 per ton of CO_2. Comparing the social costs of carbon on a BAU trajectory and on a path towards stabilization at 550ppm CO_2 eq., Stern estimated the excess of benefits over costs, in net present value terms, from implementing *strong* mitigation policies in 2006: the net benefits would be of the order of $2.5 trillion. This figure – the Review claims – would increase over time.

This optimistic result has one important caveat though: "innovation driven by strong policy will ultimately reduce the carbon intensity of our economies, and consumers will then see reductions in the prices that they pay as low-carbon technologies mature".

III.iii Policy recommendations derived from the Review

The Stern Review recommends a series of policy measures to face the climate change problem: in the long run, there must be a way to reduce GHG emissions that is *mitigation*; in the short run, there should be *adaptation*. In both sets of policy measures, the government plays an important role through taxing, regulating, providing information and public goods, and financing the poor.

[3] There is a complete section in the Stern Review for the discussion of the "discount rate" (see Stern, 2006 pp.31-32).

Mitigation

According to the Review the policy to *reduce* emissions should be based on three elements: carbon pricing, technology policy, and removal of barriers to behavioral change. It is emphasized that policy frameworks must deal, among other things, with interactions with a wide range of *market imperfections*.

With respect to carbon prices the idea is to establish an appropriate price on carbon –through tax, trading or regulation – so that individuals and businesses are led to switch away from high-carbon goods and services, and to invest in low-carbon alternatives. But to be efficient, this price must be a common *global* carbon price. However, investors and consumers must believe that the carbon price will be maintained into the future and credibility takes time so Stern proposes a period of transition of 10 to 20 years to reach the time when carbon pricing is universal and is automatically factored into decision making. In this transitional period – Stern argues – it is critical that governments consider how to avoid the risks of locking into a high-carbon infrastructure, including considering whether any additional measures may be justified to reduce the risks.

Secondly, the development and deployment of a wide range of low-carbon technologies is essential in achieving the deep cuts in GHG emissions that are needed. While the private sector plays the major role in R&D and technology diffusion, it is very important a close collaboration between government and industry for stimulating the development of a broad portfolio of low carbon technologies and to reduce costs. Public spending on research and development (R&D) – Stern emphasizes – must be increased relatively to what has been in the past two decades when it has declined.

Moreover Stern argues that the scale of existing deployment incentives worldwide should increase by two to five times, from the current level at the time. Such measures – he says – will be a powerful motivation for innovation across the private sector to bring forward the range of technologies needed.

Stern considers that the lack of reliable information and the existence of transaction costs, and behavioral inertia constitute barriers that prevent energy efficiency measures to be effective. In that case regulatory measures could provide clarity and certainty. “Minimum standards for buildings and appliances have proved a cost-effective way to improve performance, where price signals alone may be too muted to have a significant impact” (Stern, 2006).

Adaptation

According to the Review the governments play an important role in providing a policy framework to guide effective adaptation by individuals and firms in four key areas: (a) High-quality climate information and tools for risk management; (b) Land-use planning and performance standards; (c) Long-term polices for climate-sensitive public goods, including natural resources protection, coastal protection, and emergency preparedness; (d) Financial safety net that is required for the poorest in society, who are likely to be the most vulnerable to the impacts.

IV. Nordhaus versus Stern debate

The Stern Review’s debate had various angles and many participants. A thorough analysis of this debate was done at the time by Frank Ackerman (2007) among others. In particular the criticism of Nordhaus was dealt with, also, by the outstanding economist Kenneth Arrow (2007). For the purpose of our analysis we present here, the background for this debate, the basic elements of the Nordhaus critique, Stern’s own arguments and, finally, the “crucial” discussion on the discount rate between the authors above mentioned. Three basic aspects of the debate are involved: how expected damages were estimated; how uncertainty is treated, and the discount rate.

IV.i Background

Before Nicholas Stern was appointed to do the economic inquiry that was eventually known as the “Stern Review”, there had been some global models for analysing the evolution and predictable impacts of climate change and global warming on earth’s social and economic life, and deriving from it some policy

recommendations to cope with it.

Even before the famous James E. Hansen's Statement before the US Senate Committee on Energy and Natural Resources hearing, called "The Greenhouse Effect: Impacts on Current Global Temperature and Regional Heat Waves" in June 1988 (Hansen 1988), there was a not less famous work called *Changing Climate, Report of the Carbon Dioxide Assessment Committee*. This was published in 1983 by the National Academy Press and edited by the chairman of the Committee, William A. Nierenberg. It collected the works of several scientists evaluating Climate Change, among which there are two chapters by William D. Nordhaus, and two other colleagues of him.

Nordhaus has been the leading economist of the University of Yale, in New Haven, U.S.A., for *General Equilibrium* models dealing with Climate Change. His modelling on energy can be traced as far back as 1973. The initial relevant work done in the seventies was his energy model of 1979 for the US energy sector where he tries to determine the prices of energy resources, for an *efficient* use of those resources (called "efficient prices"). The investigation was oriented towards establishing the time pattern of the efficient use of the energy resources assuming that those resources – which are scarce – have a royalty attached, that increases over time with the market interest rate. The difficulties the study finds in trying to adapt economic theory to real world facts – for instance the assumption of competitive oil markets that yield competitive oil prices versus actual oil prices determined by some degree of monopoly in the real oil market – leads the investigation to formulate the actual question of "what is the chance that global environmental effects will appear as a result of unrestricted market forces?" In answering this question Nordhaus concludes that "we are probably heading for major climatic changes over the next 200 years if market forces are unchecked". He, therefore, proposes a "carbon tax" as the *most efficient* control strategy (Nordhaus, 1979). The existence of non-competitive markets brings about some degree of uncertainty which adds to that inherent to the costs of new technologies estimates. It is, therefore, recognized that the validity of the results in this type of models is restricted by the very optimistic assumptions that there are no significant impediments for the action of market forces (Nordhaus, 1979).

In the 1983 report, the chapter by Nordhaus and Yohe presents a world probabilistic model for estimating CO_2 emissions as influenced by major uncertain variables or parameters. The technique utilized is called "probabilistic scenario analysis". The model is a highly aggregated model of the world economy and energy sector. The main equation is a multi-input production that related Gross National Product to labour, fossil fuels and non-fossil fuels inputs. The so called "key uncertainties" included in the model are, the rate of population growth, the availability and cost of fossil fuels, the productivity growth rate, and some others. The important findings in this model are "odds are even whether the doubling of carbon dioxide will occur in the period 2050-2100 or outside that period… it is a 1-in-4 possibility that CO_2 doubling will occur before 2050 and 1-in-20 possibility that doubling will occur before 2035" (Nordhaus and Yohe, 1983, p. 94). This chapter includes the projected CO_2 world's emissions and its rates of growth from 1975 to 2100, all of which are meaningless by now. The chapter by Ausubel and Nordhaus is a review of projections of CO_2 emissions and concentrations for 2100, which depend mainly on energy consumption levels and the substitution of fossil fuels for other energy sources, made by various experts including Nordhaus himself. Except for the recommended use of a tax on carbon-based fuels as the most efficient policy to stabilize or even reduce CO_2 emissions, the study does not go any further, since there is no analysis of Climate Change economic impacts or costs.

Nordhaus' "DICE" model is presented in 1992 (Nordhaus, 1992). It is called DICE for a Dynamic Integrated Climate Economy model. "The model is an optimal-growth model for the world economy. It is designed to maximize the discounted 'utility' or satisfaction from consumption subject to a number of economic and climatic constraints. The global economy is assumed to produce a composite commodity. The composite economy is endowed with initial stock of capital and labour and an initial level of technology and all industries behave competitively. Each country maximizes an inter-temporal objective function identical in each region which is the sum of discounted utilities. Population growth and technological change are exogenous. There is no need for international trade since the outputs of the different countries are perfect substitutes".

One important feature of this model is that it is assumed that "GHG emissions can be controlled by

increasing the prices of factors or outputs that are GHG-intensive". The presentation also says that the model can be interpreted either as an optimizing framework or as an outcome of idealized competitive markets. It is assumed that the public goods nature of climate change is "somehow overcome in an efficient manner. That is, it assumes that, through some mechanism, countries internalize, in their decision making, the global costs of their emissions decisions".

The important conclusions from this version of Nordhaus' model results are that "an efficient strategy for coping with greenhouse warming must weigh the costs and benefits of different policies at different points of time…Estimates of both costs and damages are highly uncertain and incomplete…In terms of damages… the impact of climate change coming from a 3°C rise in global mean surface temperature…is estimated to be a about 1.3 of output for the global economy" (Nordhaus, 1992).

As an improvement of the DICE model, a new model called RICE is presented in 1996, by Nordhaus and Yang. The name stands for Regional Integrated model of Climate and the Economy. This is described as a regional dynamic general equilibrium model of the economy which integrates economic activity with the sources emissions and consequences of greenhouse-gas emissions and climate change. By disaggregating into countries the model analyses different national strategies in climate change policy. The model asks how nations would in practice choose climate-change policies in light of economic trade-offs and national self-interests for reductions of GHGs. In the RICE model the world is divided into 10 regions, each is endowed with an initial capital stock, population, and technology. Of these three variables capital accumulation is determined by optimizing the flow of consumption over time.

From to the results of the model there are some basic conclusions. The most important one is that the model estimates the difference between cooperative efficient policy and the non-cooperative policy. This latter is one in which countries maximize their economic welfare taking policies of other countries as given. "This implies that small countries whose climate change policies have little effect on their own economic welfare, will have little incentive to reduce emissions while the largest countries will have greatly attenuated incentives to engage in costly reductions in CO_2 emissions" (Nordhaus, 1996).

The results of the model indicate that the stakes in controlling global warming are *modest* in the context of overall economic activity over the next century. The estimates indicate that losses from global warming will be in the range of 1 to 2 per cent of global income over the next century. According to the model successful cooperation would lead to net gains, but the failure to cooperate is unlikely to lead to economic disaster over the next century.

In *Roll the DICE again: Economic Models of Global Warming* by Nordhaus and Boyer (1999) the authors made a detailed description of Nordhaus' general equilibrium world models built until then and they run a new version of DICE. The model called RICE-99 estimates damage functions for both the world and by region and sector. The results seem to be of the greatest importance: "The results differ markedly by region. The impacts (of a 2.5°C global warming) range, from a net benefit of 0.7 per cent of output, for Russia, to a net damage of almost 5 per cent, for India. The global average impact is estimated to be 1.5 per cent of output, using projected output weights and 1.9 per cent of output using 1995 regional population weights". "Current projections of RICE-99 indicate that total warming in an uncontrolled environment will be slightly below 2.5°C around 2100. Our estimate is that damages are likely to be around 1.9 per cent of global income using 2100 output weights. The damages for the US, Japan Russia and China are essentially zero over that time frame, assuming that catastrophic scenarios do not materialize. Europe, India and many low income regions appear vulnerable to significant damages over the next century", (Nordhaus and Boyer, 1999).

We see that as early as 1979 Nordhaus was aware of the need to have free market forces *under control*, in order to prevent a major "climatic change" over the next two centuries, if they were *unchecked*. The policy measure for "control" he proposed then – and became eventually his basic policy instrument all along his writings – was a *carbon tax* that would induce consumers and producers to switch from fossil fuels' energy to other sources of energy. For Nordhaus this carbon tax was the most efficient policy, which means *optimal* in Pareto's terminology. However, in the same analysis, he recognizes one big problem in his model which was – and still is – the assumption of perfect competitive markets, that introduces some degree of uncertainty on the validity of, at least some of, its predictions.

IV.ii Nordhaus on Stern

Shortly after the Stern Review was made public, Nordhaus published an article commenting on this Review mostly in a critical way (Nordhaus, 2006).

He starts by stressing how large in size the results of Stern projections were with respect to the estimates of losses from climate change damages, in terms of global GDP, under the BAU trajectory: "the *Review* estimates that if we don't act, the overall costs and risks of climate change will be equivalent to losing at least 5 per cent of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20 per cent of GDP or more". These results – says Nordhaus – are especially dramatic when contrasted with those from "earlier economic models that use the same basic data and analytical structure", which one might presume are mainly those of Nordhaus himself. More to the point, Nordhaus states that those earlier models' results led to "efficient or optimal policies to slow climate change [that] involve modest rates of emissions reductions in the near term followed by sharp reductions in the medium and long term". This is what he calls "climate-policy ramp".

Nordhaus critical points are essentially these: first, "…while I question some of the Review's modeling and economic assumptions, its results are fundamentally correct in sign if *not in size*"; second he criticizes that the Review is not an academic study since it was not peer reviewed, therefore it should be viewed as a *political* document; and third, the most important, "….the Review's radical revision arises because of an extreme assumption about discounting. Discounting is a factor in climate-change policy – indeed in all investment decisions – which involves the relative weight of future and present payoffs… The Review proposes using a social discount rate that is essentially zero. Combined with other assumptions, this magnifies enormously impacts in the distant future and rationalizes deep cuts in emissions, and indeed in all consumption, today. If we were to substitute more conventional discount rates used in other global-warming analyses, by governments, by consumers, or by businesses, the Review's dramatic results would disappear, and we would come back to the climate policy ramp described above".

Besides these critical comments Nordhaus points out only one of Stern's policy measures which he apparently endorses: "the Review argues that it is critical to have a harmonized carbon tax or similar regulatory device both to provide incentives to individual firms and households and to stimulate research and development in low-carbon technologies. Carbon prices must be raised to transmit the social costs of GHG emissions to the everyday decisions of billions of firms and people".

IV.iii Stern's arguments

Oversized predictions and policy

If you compare Stern's projections of GHG emissions under the BAU trajectory shown in Figure 2 in Section III and the one from the current OECD's projection shown in Figure 1, Section II, you don't see much difference. Look at both graphs at the point of year 2050, and the only difference you'll notice is that while for Stern there will be still some GHG emissions from Land use, for the OECD there will be none, the estimated emissions from Land use per year are the difference between the two graphs, it is very little and based on different assumptions. So, Stern's GHG emissions projections were not particularly *oversized*. Therefore, the problem comes from other results of the Stern Review's model, those referred to the relation between global mean temperature increase and damages costs, both resulting from climate change.

At this point we must recall the strongest of Stern's prediction regarding global warming: "Under a BAU scenario, the stock of greenhouse gases could more than treble by the end of the century, giving at least a 50 per cent risk of exceeding 5°C global average temperature change during the following decades. This would take humans into unknown territory". In other words, in the extreme case, that is, over 5ºC of increase in average global temperature, we could not even assess the magnitude of the damage involved, much less the costs in this future, beyond 2100.

But even at temperatures not as high, Stern clearly points out: "the monetary impacts of climate change are now expected to be *more serious* than many earlier studies suggested, not least because those

studies tended to *exclude* some of the most uncertain but potentially most damaging impacts. Thanks to recent advances in the science, it is now possible to examine these risks more directly, using probabilities". The question of probabilities is put, therefore, at the center of Stern's analysis, so he uses the model called PAGE 2002 that takes into account "the range of risks by allowing outcomes to vary probabilistically across many model runs, with the probabilities calibrated to the latest scientific quantitative evidence on particular risks". Stern's projections of global temperature increases and monetary losses from climate change are presented within range of probabilities.

It is important to emphasize on some aspects regarding Stern "oversizing" costs and damages from climate change. Indeed, the expected damages and their costs in terms of GDP resulting from Stern model are higher than those which other models predicted before, in various ways and for various reasons. These are, in particular with respect to GHG concentration and global temperature increase: (1) the probability of reaching a higher level of GHG concentration in the atmosphere by 2050 and 2100, (2) the chance that this higher concentration leads to reach higher global temperature levels before previous estimated times and (3) the consideration of amplifying feedbacks in the climate system from climate change.

This probable new scenario of climate change has a higher than predicted monetary impact in all countries in terms of damage costs, with developing countries suffering even more than the average. Stern explicitly states that his model's results in monetary terms are even worse, when incorporating three factors, other models did not: (1) non-market impacts costs; (2) amplifying impacts costs and, (3) appropriate weighting of the unequal distribution of damages form climate change, for poor countries.

Therefore, the policy actions that Stern proposes have these characteristics: immediate starting, strong and including a wide variety of measures in which the role of the state is indispensable. This contrasts to what Nordhaus had proposed all along his studies which was a single policy: *a carbon tax* to increase *carbon prices*. And, by the way, this policy is not excluded in the Review itself.

Uncertainty and the discount rate

We have seen so far that Stern dealt with risks and uncertainty by means of probability, but Nordhaus refers to uncertainty linked to the discount rate in his critique: "A further unattractive feature of the Review's near-zero social discount rate is that it puts present decisions on a hair-trigger in response to far-future contingencies. Under conventional discounting, contingencies many centuries ahead have a tiny weight in today's decisions. Decisions focus on the near future. With the Review's discounting procedure, by contrast, present decisions become extremely sensitive to uncertain events in the distant future".

To begin with let's see what Kenneth Arrow says in that respect: "Critics of the Stern Review don't think serious action to limit CO_2 emissions is justified, because there remains substantial uncertainty about the extent of the costs of global climate change, and because these costs will be incurred far in the future. However, I believe that Stern's fundamental conclusion is justified: we are much better off reducing CO_2 emissions substantially than risking the consequences of failing to act, even if, unlike Stern, one heavily discounts uncertainty and the future…Two factors differentiate global climate change from other environmental problems. First, whereas most environmental insults – for example, water pollution, acid rain, or sulfur dioxide emissions – are mitigated promptly or in fairly short order when the source is cleaned up, emissions of CO_2 and other trace gases remain in the atmosphere for centuries. So reducing emissions today is very valuable to humanity in the distant future….Second, the externality is truly global in scale, because greenhouse gases travel around the world in a few days. As a result, the nation-state and its subsidiaries, the typical loci for internalizing externalities, are limited in their remedial capacity…Thus global climate change is a public good (bad) par excellence. Cost-benefit analysis is a principal tool for deciding whether altering it through mitigation policy is warranted. Two aspects of that calculation are critical. First, it has to be assumed that individuals prefer to avoid risk. That is, an uncertain outcome is worth less than the average of the outcomes. Because the possible outcomes of global warming in the absence of mitigation are very uncertain, though surely bad, the uncertain losses should be evaluated as being equivalent to a single loss greater than the expected loss" (Arrow, 2007).

Frank Ackerman from the Global Development and Environment Institute, at Tufts University in the USA is a little more prolific in his opinion about Stern's discount rate. He argues to begin with that, in

selecting the appropriate discount rate for long-term public policy decisions we must distinguish between two elements: one is the rate of pure time preference which is the discount rate that would apply if all present and future generations had equal resources and opportunities and the other is a wealth-based component, reflecting the assumption that future generations will be richer than we are. In the Stern Review, the discount rate, r, is the sum of these two parts in the equation, $r = \delta + \eta g$, where, δ is the rate of pure time preference, g is the growth rate of per capita consumption, η is a parameter that determines how economic growth affects the discount rate. Stern estimates that the growth of per capita income will average 1.3 per cent a year and sets $\eta = 1$. Thus, Stern's discount rate is: $r = 1.4$ per cent (Stern, 2006, Ch.2).

Nordhaus' critique is in fact centered on Stern's value for δ, the discount rate that would apply if all generations were equally well off. Stern, while accepting the philosophical arguments for treating all generations equally, observes that there is a small, but non-zero, probability that all future generations will not exist. The probability of humanity's extinction is assumed to be 0.1 per cent per year. It means that pure time preference is therefore set equal to 0.1 per cent (Ackerman, 2007).

The choice of a particular δ pure time preference rate is an *ethical* question, involving the value placed on the intrinsic well-being of future generations, independent of income. Stern favors a much lower value than other economists, but the choice – says Ackerman – is not a matter of technical analysis. So in order to quantify an ethical perspective that respects and validates the future, it is essential to set pure time preference close to zero. Regarding the choice of the second parameter, the exact value of η is not crucial to the general conclusions, *i.e.*, that the benefits of active, immediate mitigation outweigh the costs.

Finally, Nordhaus argument that discount rates should match current interest rates is for Arckerman a *mistake*, because it is grounded in abstract theories of perfect markets, not in reality. Ackerman concludes that markets are imperfect in countless ways.

V. Conclusions

Despite that liberal and neoliberal economists seem to have repeatedly won the theoretical and political battle since the seventeenth century against state interventionist economists, most developed countries have reached the level of development they enjoy today and could get out of economic crises, thanks to strong state policy measures.

Free market may be considered self-regulating – and market oriented policies as first best – under very limited circumstances, which are very unlikely to exist in all countries, at all times, like perfect competitive markets, full information, etc. Actually what is more probable to exist is a situation of many *market failures*, when some of these conditions are not fulfilled by economic reality in any given country at any given time. More over when they are not met at the same time, that is, when there are, for example, externalities, public goods, imperfect competitive markets, incomplete information and principal-agent problems simultaneously, as in the case of pollution in general and climate change in particular.

Whatever the extent of market oriented policies carried out between 1988 and 2005 they did very little in solving the GHG emissions problem, called Climate Change. Nicholas Stern pointed out in his Review, in 2006 after eighteen years of IPCC foundation, that Climate Change was "…the greatest and widest-ranging market failure ever seen" (Stern, 2006). Stern also called for a "major change" – as opposed to a marginal one – in GHG reductions which, as all major changes in the economy must be led by the state in each country case.

In the so called Stern Review debate, Nordhaus' criticism only reveals the weakness of his own argument for a free-market policy, which is the set of free-market assumptions that does not hold in any real economy.

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