An evaluation of the Stern's Report on the economics of climate change
Christian Gollier (University of Toulouse)

Imagine the social consequences of an event that would reduce the world GDP now and forever by 10%. Our governments should be made responsible to act quickly by implementing any policy eliminating the chance of such an event if its recurrent yearly cost would be less than 10% of GDP. The recent report by Sir Nicholas Stern, a former chief economist at the World Bank and a highly respected researcher, suggests that this nightmare is not a pure fiction. According to Stern, if we don't act quickly to reduce our emissions of greenhouse gases, global warming will be damaging our economies by as much as 35% of GDP by the year 2200. This cost includes reduced agricultural productivity, fatalities due to natural catastrophes, damages to buildings, increased air conditioning and the loss of environmental assets. The good news of the report is that the cost of actions to reduce the worst impacts of climate change amounts to less than 1% of global GDP each year.

The Stern's report is much less optimistic than earlier studies on this question. For example, William Nordhaus estimated the cost of climate change at "only" 3% of global GDP, and a group of economists associated to Dale Jorgenson predicted a net *benefit* of global warming for the U.S. economy that could be as much as 1% of GDP for some scenarios. These disagreements among the specialists are mostly the consequence of divergences on the way to treat risk and time in the evaluation. Economists have long been concerned with the treatment of these two central dimensions of climate change, but they usually worked on infinitesimal risks and on time horizons not exceeding a few years. Stern's report is concerned with time horizons covering two centuries and with risks that could potentially threaten life on the earth. Given these challenges, it is a real *tour de force* that the report produces a credible platform to discuss policy recommendations.

Time preferences

Most of the consequences of global warming will not appear before the year 2100. For example, it is assumed in the Stern's report that the mean losses in global per-capita GDP are 2.9% in 2100 and 13.8% in 2200. Thus, contrary to what was suggested above, future generations will bear most of the costs. A crucial question is then to determine how much the current generations should be ready to pay to reduce these future costs. We all agree that one euro obtained immediately is better than one euro obtained next year, mostly because of the positive return we can get by investing this euro. This arbitrage argument implies that costs and benefits occurring in the future should be discounted at a rate equal to the rate of return of capital over the corresponding period. However, because it is hard to predict the rate of return of capital for the next two centuries, the Stern's report follows another road, which consists in evaluating explicitly the welfare effect of global warming for each future generation. Because it compares consumption paths in which costs are redistributed across generations, it is important to make explicit the ethical and economic assumptions on which these comparisons were made. Most environmental policies will generate losers and winners, but Stern's report is based on the moral statement that the socially desirable ones are those which increase the sum of each future generation's welfare discounted at a rate of 0.1% per year.

The welfare approach to discounting is based on the additional assumption that future generations will be richer than us. In a nutshell, one should not be ready to pay one euro to reduce the loss borne by future generations by one euro, given that these future generations

will be so much wealthier than us. Using the argument retrospectively, we enjoy a real GDP per capita that is approximately 50 times larger than Europeans who lived during the Napoleonic wars, and it would not have been a good idea for them to make much effort for our welfare. If we assume that the marginal utility of wealth is decreasing, increasing wealth in 1806 was much more desirable in term of intergenerational welfare than increasing wealth by the same amount in 2006. The same relative value of wealth applies when comparing 2006 and 2206, if we expect the same growth of the economy over the period.

In the Stern's report, it is assumed that the world economy will grow at a real rate of 1.3% per annum over the next two centuries, which implies a GDP 13 times larger in 2206 than today. It is also assumed that doubling the GDP per capita halves the marginal utility of wealth. Coincidentally, Daniel Bernoulli made exactly the same assumption in his famous 1738 article in which the expected utility theory was exposed for the first time. With these time preferences and expectations, the socially efficient discount rate would be around 1.3%. This has substantial consequences for Stern, since it implies for example that one should be ready to give up as much as 60% of GDP per capita, now and forever, to raise the growth rate of GDP over the next two century from 1% to 2% per year.

I don't think that many of us will agree to sacrifice so much to improve the very distant future. Said differently, the report requires us to invest in any project whose rate of return would be larger than 1.3%. This rate is ridiculously small given the assumed growth rate of the economy in the model. The problem is that most economists believe that the marginal utility decreases much faster than what is assumed by Stern. To keep the argument simple, a person endowed with Stern-Bernoulli preferences would not be ready to pay more than 0.5% of his wealth to eliminate a fifty-fifty chance to loose or gain 10% of his wealth. We believe that most people should be ready to pay between 1% and 2% to eliminate this risk. This would be compatible with a much more wealth-sensitive marginal utility, and with an efficient discount rate between 2.6% and 5.2%. This more realistic assumption on preferences will also drastically reduce the evaluation of the permanent reduction in GDP equivalent to the welfare impact of climate change that is documented in the report.

By investing in technologies to reduce the impact of climate change in the distant future, we redistribute wealth from the poor current generations to the wealthy future ones. However, it is a fact that we do not implement policies (fighting malaria, improving access to clean drinking water,…) today that would be highly cost-effective and favourable to human beings whose wealth is less than one-hundredth than the GDP per capita of developed countries. Following the Stern-Bernoulli's assumption on preferences, developed countries should be ready to pay as much as 100 euros if only one euro could be served as a benefit to one of these very poor people. In other words, the priority should be put on helping the current people living below the poverty line rather than on fighting global warming. Worse, by actually focusing on climate change, we are going to force developing countries to divert some of the benefits of their growth, which is so useful to fight poverty, towards cutting CO2 emissions, a concern of the wealthy.

Risk preferences

There are considerable uncertainties associated to the modelling of both climatic and economic impacts of the increase of the concentration of CO2 in the atmosphere. Usually, the uncertainty is eliminated by considering a "best estimate" for the impact, and by performing a

sensitivity analysis around the benchmark. The Stern's report provides a much more clever approach to risk. Probabilistic estimations are computed for the various scenarios considered in the model. For example, contrary to previous studies, it considers the likelihood that the average temperature increases by more than 5°C (See Figure 1). The model also includes the chance of catastrophes for increases in temperature above this critical level. More specifically, this chance increases by 10% per °C rise, and the catastrophe generates losses in the range of 5-20% of GDP. Combining all sources of uncertainty in the model yields a distribution of impacts below and above the best estimate discussed earlier that is quantified by using a Monte-Carlo technique (See Figure 2). According to the Stern's report, this exercise leads to the conclusion that the best estimate for losses in the year 2200 is 13.8% of GDP, with a 90% interval of confidence that the true loss will be between 2.9% and 35.2% of GDP.

Stern takes into account that we are risk-averse, so that facing this risk of loss is not equivalent to incurring the mean loss with certainty. Again, this is because the marginal utility is decreasing, so that the chance of a large positive deviation from the mean loss has a much larger negative effect on welfare than the corresponding chance of a large negative deviation from the mean loss. The risk premium is proportional to the speed at which marginal utility decreases when wealth increases. Because, as said before, this is largely underestimated in the Stern's report, the effect of risk on welfare is largely underestimated in this report. For example, Stern gets that the psychological cost of risk in year 2200 is only 0.6% of the GDP in that year. For more realistic risk attitudes -- those that would be compatible with observed behaviours in financial markets and insurance markets --, this number should be four to ten times larger!

Another problem with this study is that it is based on values of the climatic and economic parameters that are highly speculative. This is particularly true for events in which the average temperature increases by more than 5°C. Much of the quantitative evaluations of costs are driven by the probability of a catastrophe occurring if this limit is attained, and by the quite undocumented assumption that the size of losses is a convex function of the change in average temperature. Because the calibration is based on relatively unstable scientific evidence, its result should be taken with some grains of salt. The precautionary principle suggests that we should bias our beliefs in a way that is more pessimistic than in the Stern's report.

The absence of scientific certainty about the impacts of climate change also raises the question of the optimal timing of the effort to curb emissions. A slow start could be socially efficient if we expect better information in the near future. Postponing most of the effort to after getting better information would save us large costs associated to the reduction of emissions if it happens that the signals observed in the future are favourable. In other words, postponing the irreversible effort has an option value.

The report puts much emphasis on providing the good price signals to the market. A Pigouvian tax or a market for emission permits should be organized worldwide. It should increase the cost borne by the emitters of one tonne of carbon by an amount equalling the marginal certainty equivalent discounted damages that this tonne will generate. Existing estimates vary between 50 and 100 dollars, but the current competitive spot price on the EU emission trading market is around 40 euros. If we believe in these cost estimates, this price is probably not a good signal for the market, and our governments should intervene on this market to push prices upwards, and to announce credibly that a high price will be maintained in the future.

Finally, another item of concern is about the functioning of insurance markets. In most Europeans countries, insurers are prohibited to discriminate their homeowner insurance premium on the basis of the true individual risk. For example in France, a compulsory coverage for natural catastrophes is added to the homeowner insurance policy against a uniform 12% increase in the basis premium. This implies that too many houses will be built on risky spots in the long run. It is urgent to re-examine the regulation the insurance market for natural catastrophes.

The main advantage of the Stern's report is to provide an economic basis arguing in favour of a radical transformation of our attitude towards climate change. Contrary to other ecological pamphlets based on the pure rhetoric of the vague notion of sustainable development and intergenerational equity, Stern measures the cost of doing nothing based on crude estimations of the essential parameters of the climatic and economic model. With this report, disagreements on what should be done should move from the sterile field of pure rhetoric to the discussion of the credible values of these parameters. Rather than its quantitative conclusions, the added value of this report can be found in the framework for a collective decision-making process that it provides.
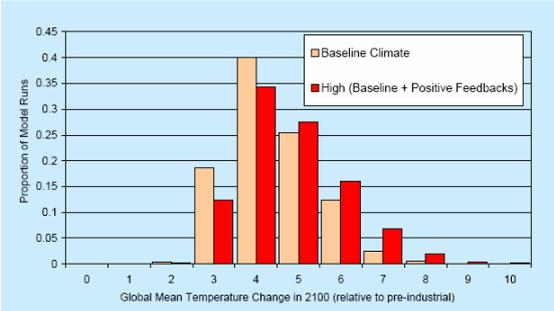
++++++++++++++++++++

Figure 1: distribution of mean global
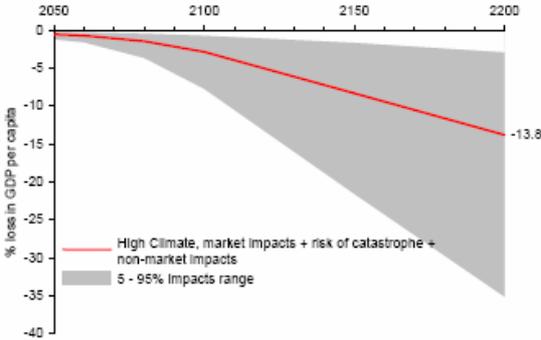temperature change in 2100.

Figure 2: Impact of climate change in percentage
loss in GDP per capita over the next 200 years.