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Environmental Discussion
And Finance

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1   What is this about?

After reviewing several texts about climate change and the possible solutions to mitigate it, I arrived to conclusion that further written discussion should be offset in a similar manner as offsetting travels!As a matter of fact I already offset my discussion planting more than 200 trees!

My proposal is the following :with obligatory taxes like payments from polluters, more offsetting and voluntary contributions we can create the fund.This fund, managed by some financial institution,is used to the emission of environmental improvements certificates. I believe that there are many financial institutions eager to do it without charging any fees.

My proposal is based on the well known Principal -Agent method, being Nature the Principal .Agent could be anyone who buys the certificate or in problems referred to deforestation, these certifcates could be given free of charges to the inhabitants of the affected community.This could efficiently stimulatethe cooperation between agents when certificates involve GRATER entities like industries, countries or even EU as a whole.

Certificates can be traded. Moreover, it is easy to design certificates such as Nash equillibrium (competitive) automatically gives one socially optimal (collusive) without any necessity of renegociation. Clearly the precise optimality of such certificates depend on given models .Construction of specific ,precise models represents the biggest failure of the cost-benefit analysis applied to environment .In our approach, GOOD environmental certficates like awarding larger number of trees or DECREASING pollutants levels are good in ANY state of nature. Only after several applications of this method we can think about precise models ,although the theoretical analysis of the optimality of certificates in well developed ones can go in "paralelum" .This is the spirit of dealing with

many problems in modern finance. We have already analyze several models but , without a real link with the states of given environmental problems .Our method addresses also the problem of what to do with environmental tax ;feed more environmental bureaucracy or apply to the developmnent or REAL market mechanisms?

I really got scared in the name of Mother Nature after reading the U.K.Environmental Secretary Miliband reply to Robert Samuelson comments-Newsweek- November13 and December 4. Mainly I do refer to the Secretary imperial tone defending scientifically undefendible Sir Nicolas Sterns report. Additionally we read" Deforestation can be avoided if people are provided with altenative ways of earning money." Beautiful, but how ?.These words reminds so called forestry proyects most of them either failed or heavily subsidized. Many of them sound-people (local) should pick up berries and sell them in the local market.

Secretary Miliband should know that local people (I assume that the Secretary has local people in mind) are only responsible for the minor part of deforestation. Unfortunately many politicians maintain the same tone of voice without concrete and funded proposals. The article written by the Secretary Miliband ,Newsweek ,February,12 can be resumed ; IF we do right things then our future will be bright.I strongly believe that polticians should propose solutions instead!

Coming back what we are aiming to,we believe that our proposal is much more efficient than caps and trade -permits to pollute approach,that often shifted the pollutants around .In the past, lack of global agreement cause collapses of the market on carbon emissions,or on the other hand ,we have Stern s "rule of thumb" imaginary price! Actual price is perhaps too cheap but price is the price if there is a market!

Of course there are more serious studies in this direction like the recent one by M.Fehr and J .Hintz from ETH Zurich.But,any kind of study like this aiming to obtain the correct price of carbon emissions needs a model (precise), and any model using past statistics about price of gas can not be precise by its nature.The pricing of carbon emission was based in this study on switching into gas burning policy.

Even less precise are sudies concerning any change of technology . There is a beautiful research in this direccion by Robert Elliott from the University of Calgary ;but even if his models were correct qualitatively ,they needed very precise parameters if ever put in practice.

We finish the descriptive part with the quotation" lies ,damn lies ,and statistics" which in environmental studies is still alive ,and stress that our method should be applied separately to different environmental topics- to avoid lies, statistics and endless discussions of the kind ; how much credits should be given

for planting trees ?

In the mathematical part we consider optimization problems cocerning co-operation mechanisms beteen two polluting entities and/or agents -tenants of improvement certificates .

Our proposal represents new branch of optimization problems in Mathematical Finance and, because of its importance for applications to the environment,deserves proper attention.

2   What we have now?

Frogs and boys:
Boys were throwing stones into frogs. Suddenly one frog said: stop, for you it is just fun but for us, our life is in stake.
Mathematical finance $\longrightarrow$ play
Environmental finance $\longrightarrow$ life
Earlier studies, e.g. Bedlewo.
Optimization problems based on P-A approach for one process.
Improvements: reforestation, reduction of pollution ...
We have solved several analytical problems with heavy use of Exponential martingales, Girsanov ...

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Presentaion is more conceptual, but also we will present examples.
Method:

1) Principal issues certificates

2) Agents act in their optimal way

Principal problem: Certificates that ensure optimality under specific goal.
Optimality of certificates depends heavily on models, but "Nature resists imitations through model"

Schrödinger

We shall conform with much more modest approach:analysis of good certificates, such that contribute positively to environmental improvements in any state of nature.
What we have?

1) Pollution levels increase last year

2) Deforestation levels become every year more dramatic

To improve: Permits to pollute solution proposed based on Kioto and beyond.

Distortions:

1) Price $[0.2, 27]$ and no regulations

2) Now or tomorrow: with discount factor of obout 4%

the benefits beyond some years barely count.
Two pathetic examples:

a) Polluting factory bought (virtually) mango plantations in India. So they can pollute more.

b) The pig farm in Chile promised to recycle its animals emission of methane. In return, the power companies bought the right to emit more carbon dioxide. Companies: in Japan and Canada.

Permits to pollute are in a sense a kind of linear tax paid by polluters; why linear?
"Carrot" solutions:

1) US to cut Guatemalas's debt for not cutting trees

2) Creation of national parks in third world: saves the forest? (We can declare National Park the whole planet- and what?)

3 Proposal

Conditional carrots (and sticks) at different levels, for example, states, countries

a) If you pollute $\longrightarrow$ have to pay some contribution (non linear) to the fund, not limited to the polluters. Another contributions from offsetting (International panel on climate change joined 800 scientist and should be offset) or ...just who wants.

b) From fund to certificates.

Fact and not wishful thinking: The fund is managed by a financial institution without charges at least in the first stage.

Different environmental problems should be treated separately. US wants more "credits" for planting trees (EU less). We can not expect good results because we have no agreements. It is desirable a joint efforts of agents (tenants of certicates) and creation of coalitions. But the most important fact is that the mismatch between Nash and collusive equilibria less important.

In our approach the transfer of pollutants related to permits to pollute is of no importance; left to the market.

More transparency $\longrightarrow$ More efficiency
Larger fund $\longrightarrow$ More improvements

4 Analytical part

Let us start with the popular example:

E_i pollutant levels produced by countries, $i = 1, 2$. Each country cost $\frac{1}{2}\left(E_1 + E_2\right)^2$.

Cost of abatement are :

Country 1 : $2\left(1 - E_1\right)^2$ Country 2 : $2\left(1 - E_2\right)^2$

Socially collusive optimal levels are :

$$E_1 = \frac{6}{10}, \qquad E_2 = \frac{2}{10}$$

But Nash levels are much higher.

Proposed solutions:

a) Taxes

b) Regulations & repeated games

But the main goal is lost, being the main goal: reduction of pollutants as much as possible. Comming back to our proposal issue of certificates that could be

$$S_1 - \frac{1}{2}(\alpha E_1 + E_2)^2 \quad \text{or} \quad S_1 - \frac{1}{2}(E_1 + E_2)^2 - AE_1$$

$$S_2 - \frac{1}{2}(E_1 + \beta E_2)^2 \quad \text{or} \quad S_2 - \frac{1}{2}(E_1 + E_2)^2 - BE_2$$

$A = B \longrightarrow$ uniform tax

The precise form of the certificates beomes here of secondary importance. Exist A, B or α, β such that Nash = Socially optimal with the restriction that Fund $\geq$ cost of abatement(transfered to agents). In this approach we have automatically that:

Larger fund $\longrightarrow$

Larger $A, B \longrightarrow$ Less pollution

5 Dynamical stochastic models in diffusion setting. Collusive versus Nash

We have mainly two techniques:

1) Dual (martingale) approach

2) Direct Bellman approach

Certificates are of the general form:

$$S - \int_0^T F(x(s), y(s)) ds$$

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In few examples can be solved explicitely. This kind of certificates based on temporal mean are not exactly covered by Kramkov-Schachemayer approach that in our setting can be expressed as certificates

$$C - \int_0^T \Pi_t dS(t) + X_T$$

where X_T does not depend on the agent's action.

Solution? discretization in small intervals and Backward induction. Example solved by dual technique.

$$dX(t) = \gamma_1 X(t) + \alpha_1 \xi_t dt + \xi_t dW_t^{(1)} - \delta_1 u_t dt$$

$$dY(t) = \gamma_2 Y(t) + \alpha_2 \eta_t dt + \eta_t dW_t^{(2)} - \delta_2 v_t dt$$

w_1, w_2 for example are independent. Each country cost is for example:

$$\frac{3}{2}(X(t) \cdot Y(t))^2$$

Certificates $(X(t) + Y(t))^2$ would produce $X(t) = 0$ or $Y(t) = 0$ and is not natural. (Can be fixed with a kind of transfer of pollutants)

Agents have the cost

$$\int_0^T \frac{u^2(s)}{2} ds \quad \text{and} \quad \int_0^T \frac{v^2(s)}{2} ds, \quad \text{respectively}$$

optimal collusive and Nash actions can be obtained with the use of standard dual technique. For collusive optimal minimize (in "small" time interval)

$$E\left(3X^2(t) \cdot Y^2(t) - \lambda X(t) \cdot Z_1(t) - \mu Y(t) Z_2(t)\right) +$$

$$E\left(\int_0^t \frac{u^2(s)}{2} - \lambda u(s) Z_1(s) ds\right) +$$

$$E\left(\int_0^t \frac{v^2(s)}{2} - \mu v(s) Z_2(s) ds\right)$$

$$X(t) = \left(\frac{(Z_2(t) \cdot \mu)^2}{6 Z_1(t) \cdot \lambda}\right)^{\frac{1}{3}}$$

$$Y(t) = \left(\frac{(Z_1(t) \cdot \lambda)^2}{6 Z_2(t) \cdot \mu}\right)^{\frac{1}{3}}$$

$$Z_i(t) = e^{-\gamma_i \cdot t} \mathcal{E}\left(\int_0^{\cdot} \alpha_i dW_s^{(i)}\right)_t$$

λ, μ Lagrange multipliers such that

$$E\left[\lambda X(t)Z_1(t) - \lambda \int_0^t u(s)Z_1(s)ds\right] = \lambda x_0$$

and similar equation for μ.

To simplify assume "equal" countries (the same parameters). For separate actions using Nash, pollution levels are larger by the factor $\sqrt[3]{\frac{144}{9}}$. We assume here the full observation of the uncertainty of one country by the other. To match Nash with collusive certificates must be $S_i - 3\left(X(t) \cdot Y(t)\right)^2$ for each country. So the countries must cooperate.

This is the extreme case. Example solved by Bellman:

$$dX(t) = \gamma_1(X(t) + Y(t))dW_1 - Au_t$$

$$dY(t) = \gamma_2(X(t) + Y(t))dW_2 - Bv_t$$

Each country cost is:

$$\int_0^T (X(t) + Y(t))^2 \alpha dt$$

$$\int_0^T (X(t) + Y(t))^2 \beta dt$$

Note

The same solution works of factors $\delta X(t)$ and $\delta Y(t)$ are added to drift and the same discount applied to countries costs. Now collusive optime gives:

$$W_t(t,x,y) + \frac{1}{2}W_{xx}\gamma_1^2(x+y)^2 + \frac{1}{2}W_{yy}\gamma_2^2(x+y)^2 -$$

$$\frac{1}{2}(A^2 + B^2)W_x^2 + (\alpha + \beta)(x+y)^2 = 0$$

Solution:

$$W(t,x,y) = (x+y)^2 f(t), \quad f(T) = 0.$$

$f(t)$ solves trivial Riccatti equation.

Now

$$E(X(t) + Y(t)) = E\left(\int_0^t g(s)(X(s) + Y(s))ds\right)$$

and $E(X(t) + Y(t))$ is explicite.

Nash equilibria:

For country "I":

$$W_t(t,x) = \frac{1}{2}W_{xx}\gamma_1^2(x+y)^2 - \frac{A^2}{2}W_x^2 + \alpha(x+y)^2 = 0$$

and similar equation for the country "II".

Again we have

$$u(x) = 2(x+y)f_1(t)$$

and

$$E\left(X(t) + Y(t)\right) = \int_0^t h(s)(X(s) + Y(s))ds.$$

It can be seen that once again:

$$E\left(X(t)^N + Y(t)^N\right) > E\left(X(t)^C + Y(t)^C\right)$$

We can prove easily the following Theorem.

For any bounded models one can introduce certificates that Nash = collusive for previously preestablish goal but I do not think that this leads to important consequences for environment!

Without the aid of others we could no secure for ourselves or supply to others the things that Nature requires.

Cicero, On Duties

So please help.