Environment & Financial Markets

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Abstract

We propose to put the environment into financial markets. We shall explain how to do it, and why the financial approach is practically the only one able to stop and invert environmental degradation. We shall concentrate on deforestation, which is the largest environmental problem in the third world, and explain how to start the project and what kind of optimization problems should be solved to ensure the optimal use of environmental funds. Eamples with numerical solutions are included.

Key words: Environment, Deforestation, Options, Optimization under frictions. [1]

Introduction

We argue that practical solutions for the environmental degradation are in a short supply. Most of the increasingly complex models set off different opinions about their applicability. Models should be well specified. It means that inputs should be observed or estimated. This requirement is hard to meet in environmental studies. Thus, the efficient global environmental decision–making becomes very difficult. Moreover politicians often tend to justify their decisions by inappropriate theories. This situation leads to proliferation of ineffective studies and waste of resources.

Nowadays, financial institutions cooperate in the creation of the financial markets following what is called Merton's spiral (Merton & Bodie, 1995). We shall propose to apply this approach in the solutions of some of the environmental problems. It could result in more transparent transfer of funds and the involvement of everybody concerned. Also we can expect that the transparency could stem in an increment of these funds.

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We shall focus on the issue of deforestation due to its importance for the global well–being, and the possibility to assess the number of trees.

This is not a paper about statistics or numbers. We will mention only that the annual deforestation rate is about 60,000 square miles.

Section 2 is our proposal. Although the choice of any particular model is, at this stage, only of secondary importance, the primary goal being to start the project, in Jeanblanc & Szatzschneider (2002) was chosen as a dynamical model for the number of trees in a given region a $\mathrm{BESQ}_{\beta}^{\delta}$ process, which in financial language is 0-th dimensional (therefore without mean reversion) Cox,Ingersoll & Ross model for interest rates. Geometric Brownian Motion, could be an alternative model, and we shall use it in this study.

Our approach is based on a positive involvement of holders of "good" options bought or, in the first stage, obtained for free. In the case of the forest "good" means a kind of Asian call option. We hope that it is clearly understood why Asian and why call, "Bad" options are of course put options. We will show that, in a natural way, three kinds of optimization problems crop up:

1)Individual agent problem.

2)Local optimization problem.

3)Global optimization problem.

The first one is how the holder of a good option could eventually contribute to reforestation. The second one is how to choose prices of "good" and eventually "bad" options, to maximize the space mean of the temporal mean of the "asset" in given place. The last one is how to distribute funds into particular projects.

The situation is slightly resembles the study of Executive stock options by Cadenillas *et al* (2002).

However in our approach the situation is more complicated. We must work with more difficult to analyze kind of Asian options. In this study we will present a technically more modest approach in the case of geometric Brownian motion. To create a market we propose three stages of actions:

1) Choose a place, and give "good" environmental certificates, which we will call options free of charges to the habitants of the community.

2) Sell good options.

3) Create a market with "good" and "bad" options.

The last stage can't be developed without applications of the second one. The first stage is a particular case of the stage two, which analysis forms the central part of this study.

Finally we will briefly mention valuation topics.

1. General Discussion

We shall list some of the controversial answers meant to solve a number of environmental problems.

1) Some studies call for (J. Oates, 1999) the governmental support of the projects of the reforestation in Africa. The author draws examples from India, where such programs apparently show some positive results. However, the initiative to apply them in Africa shows a poignant lack of knowledge about differences between religions, cultures and regions. The level of corruption in law enforcement in the third world countries is of such magnitude that even the most efficient government is not able to deal with the forest disappearance in the foreseeable future. As Oates rightly points out rural communities in the undeveloped countries "typically have hierarchical structure dominated by a few powerful individuals who advance their own interests". However, these individuals can act within our project.

2) Other studies support solutions based on the community actions like opening the local banks and issuing local currencies. As an example we give a course offered in Schumacher College U. K., International Centre for Ecological Studies. Yet, there are many examples of the cases when these banks disappeared with all the money deposited.

3) The experience shows that the acknowledged permits to pollute provoke disagreements concerning, for instance, the number of credits that should be gained by the reforestation. The differences in opinion convert "permits to pollute" into the problem of optimal transfer that not necessarily implies environmental improvements.

4) The solution proposed by the World Resources Institute calls for the elimination of timber subsidies and inclusion of the full value of forests into the countries well being. Then again, the question how to measure the value of forest remains open and particularly hard to apply in third world countries where deforestation takes place.

5) The individual incentives like the tax reduction operate very slowly mostly because of the spread, still far from matching, between prices of production of clean and polluting energy.

6) Last but not least, the ethical proposals that tend to inspire positive environmental actions often lack the clarity of the fundamental concepts, Crabbe *et al.*, (2000) crucial for making decisions.

Many other environmental actions are criticized in A. Fitzimmons "Defending Illusions"(1999). To the best of our knowledge this book is the only place in which the possibility of the creation of markets on environmental topics is mentioned: "Suppose that the WPCs (Wetland Protection Certificate) could be bought and sold. But where is the market for WPCs?...Congress can simultaneously establish a market for WPCs"

2.Financial analysis of the second stage

2.1 The model before the financial intervention

To model the number of trees in a given region was proposed in Jeanblanc and Szatzschneider (2002) a 0-th dimensional squared Bessel process, $X(t)$, $t \geq 0$, with negative drift defined by:

$$dX(t) = 2\sqrt{\sigma X(t)}dW(t) + 2\beta X(t)dt$$

where $X(0) = x_0 \geq 0$,and $\beta < 0$.

This choice was justified by heavy traffic approximation of the corresponding Piecewise Deterministic Markov Process as explained in our previous study which contain solutions of relevant mathematical problems within this model. Starting from different assumptions the heavy traffic approximation could lead to Geometric Brownian Motion:

$$dX(t) = \sigma X(t)dW(t) + \beta X(t)dt$$

where $X(0) = x_0$.

In what follows we specify $\sigma = 1$. This will be the model analyzed here.

2.2.1 Financial Intervention. Local goal

Suppose that given a fund Σ, the bank sells "good" (a sort of call) options on the number of trees in a given area, which we want to reforest.

Assume that one option is sold. We will clarify this assumption soon. While selling good options the bank should choose the optimal (also we will clarify soon what does it mean) price c, and the strike price k, in an award (which we call option):

$$\frac{\Sigma + c}{k - k_1} \int_0^1 (X(s) \wedge k - k_1)_+ ds$$

where k is the maximal capacity, and

$$dX(s) = X(s)dW(s) + BX(s)ds,$$

$X(0) = x$, $a \wedge b = min(a, b)$, and

$$a_+ = \begin{cases} a & \text{if } a \geq 0 \\ 0 & \text{if } a < 0 \end{cases}$$

This kinds of options are easier to handle (due to the presence of k) than Asian options. With the factor $A = \frac{\Sigma+c}{k-k_1}$ the bank will never loose money and unused funds will go to another project.

We take for example one year as the horizon, although a dynamical approach with several moving horizons could be more appropriate. This extension would produce only minor changes.

Optimal local goal means that after the optimal agent's action

$$E[\int_0^1 (X(s) \wedge k)ds]$$

will be maximized. In the agents optimization problem we shall assume their linear utility. In this case the number of sold options is irrelevant in both: local and agents optimization goals. Only one comment is needed. This option can be traded and this fact would eventually cause the concentration of capital in the hands of powerful individuals with positive effects. Only powerful individuals are able to face timber barons! In what follows we shall consider exactly one option sold. Trying to introduce another utilities would cause additional difficulties

2.2.2 Financial Intervention. Agent's approach and back to local and global goals

We assume that an agent will act in the optimal way, maximizing his or her linear utility. It means that an agent can modify (if worthy) the original "asset" into

$$dX(s) = X(s)dW(s) + BX(s)ds,$$

$X(0) = x$. Here $B \geq \beta$, $x_0 \leq x \leq k$.

Assume that the cost of agent's involvement, if worthy, is

$$c + c_1(x - x_0) + c_2(B - \beta) \int_0^1 (X(s) \wedge k)^p ds.$$

c_1 is clearly the cost of planting (easy to set) and the cost of protection can be written as the product of 2 factors: cost of changes in the tendency and cost of actual state.We will set $p = 1$.

Now agent's linear utility can be expressed as

$$A\Big(\int_0^1 E(X_s - k_1)_+ ds - \int_0^1 E(X_s - k)_+ ds\Big)$$
$$-c - c_1(x - x_0) - c_2(B - \beta)\Big[k - \int_0^1 E(k - X_s)_+ ds\Big]$$

Given optimal (for any choice of c and k_1) B^* and x^* we can choose optimal c and k_1 to maximize $E\int_0^1 (X_s \wedge k)_+ ds$.

We remind that $A = \frac{\Sigma + c}{k - k_1}$ and therefore c is significant to solve the problem. The global goal is how to distribute the global environmental fund into particular projects to get optimal overall reforestation. Some "weights" can be included to stress more importance to predetermined environmental goals.

In the next section we will solve numerically one example.

2.2.3 An example with conclusions

We take as an example the area of $100km^2$. Assume that the agent's gain should be at least $\frac{c}{3}$, being c as before the price of the option. In very first applications the agent's investment must be very attractive! The agent's return could be lower in the future. We assume $B \leq 0$ and the following initial data

$\beta = -1$, $k = 20$, $X(0) = 1$, $\sigma = 30$, $c_1 = 1$, $c_2 = 0.05$, and additional constraint $c \geq 3$.

The optimal solution is

$c = 3$, $k_1 = 2$, $x^* = 14.5$, $B^* = 0$, $local\ goal = 12$, $agent's\ gain = 1.2$. Here k, $X(0)$, σ, c, k_1, x^*, local goal, and agent's gain are expressed in millions of dollars.

Using this example and some crude approximations, we conclude that using our approach the overall deforestation could be stopped with 40 billion dollars. This amount seems high. However it could easily be bearable if the transfer of money from rich toward poor countries would be not unconditional, often supporting corrupt governments and inefficient local bureaucracy, but instead depend on concrete and predetermined environmental improvements.

Our proposal is that this conditional support should flow through market mechanisms.

In microscale, instead of compensations for local communities, particularly in protected areas, as proposed for example by James *et al.* (1999) we claim that direct involvement in conservation tasks would have better effects.

2.3 Comments about financial markets on environment

Since we are aiming at that creation of markets out of the environment, we have to answer the following question. Are there any opposite interests that help create the market? Referring to this question and taking once again reforestation as an example, we can clearly identify opposing views. On one hand, reforestation is desired by:

1.The general public

2.Tourism,although excessive environmental tourism can be harmful as shown by the Galapagos example.

3.Lumber industry with long term vision.

4.Benefits of "analog forestry"

On the other hand it is clear that not everyone embraces it, such as:

1.Cattle ranches and milk industries

2.Myopic Lumber industries

3.Constructions industry, particularly in suburban zones

We finish this section with the comment that envirommentalists could buy bad options and do nothing. This would increase the fund because bad options should be expensive. It could be like a lottery ticket purchased for a good cause.

2.4 Comments about the Valuation.

Our main goal is that holders of good options would contribute to the reforestation.

The problem is similar to the one of executive options on company stock. One could expect that in this case an executive would work a little bit harder. This problem was analyzed recently by Cadenillas *et al* (2002).

Prices of executive options can violate risk neutral valuation because executive options cannot be sold.

Our situation is different; $X(t)$ is an observable physical asset, and not one that incorporates future expectations. Positive action is work involving and we can see this work as "antidividends". Negative action (cutting trees) produces a profit, meaning dividends. This could be expressed with constant rates in risk neutral valuation as follows:

$$r \sim> r + \delta_1 - \delta_2$$

$$\delta_1 - \text{rate of work}$$

$$\delta_2 - \text{rate of profit}$$

Financial options can give forest a market value, which clearly doesn't reflect its real value.

Final Comments

We argue that is well specified. Cost can vary from place to place but it seems not very hard to estimate them. The most difficult is how to estimate β. We can expect here only low quality data. Although it is well known that β is hard to estimate even with reliable data. However, financial optimization problems have to cope with this.

So how do we reforest? Particularly what kind of trees are useful for the ecosystem in question? The inclusion of this factor could give us more parameters in our optimization problems. However the main technique would remain unchanged.

Many other environmental topics can be treated in a way similar to what we have proposed. For example:

1)A number of solar panels in a given region

2)Emissions of CO_2

Of course it would be difficult to apply this approach to the problem of vanishing genes or fish (It is very difficult to count fish). But with these exceptions our method seems to have global applications.

Finally we would like to quote Philip E. Graves from University of Colorado.

"To the extent that we value public goods, we also realize that getting extra income to buy them will accomplish nothing. There is no market to which we can buy, say, reduced CO_2 level or endangered species preservation", and in another study "but those who are frustrated by their inability to buy the environmental goods that they want, regardless of the income they generate, have few options".

We hope that our study proves that now is a proper time to change things.

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