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 for applications of the project.

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. Thus, the efficient global environmental decision–making becomes very difficult.

Ar the same time, 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.

We shall focus on the issue of deforestarion 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

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for the number of trees in a given region a $\mathrm{BESQ}^{\delta}_{\beta}$ process, which in financial language is 0-th dimensional (therfore without mean reversion) Cox,Ingersoll & Ross model for interest rates. Geometric Brownian Motion, could be an alternative model.

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, there crops up two kinds of optimization problems crop up:

1)Individual agent problem.

2)Global optimization problem.

The former is how the holder of a good option could eventually contribute to reforestation. The latter one is how to choose prices of "good" and eventually "bad" options, to maximize the space mean of the temporal mean of the "asset".

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 kinds of Asian options. In this study we will present a technically more modest approach in the case of geometric Brownian motion and only with the presence of good options. 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 individual who advance their own interests". However, these individuals can act as natural agents within our project.

2) Other studies support solutions based on the community actions like opening the local banks and issuing local currencies. 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 Word 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 ramains open.

5) The individual incentives like the tax reduction operate very slowly mostly because of the spread, still for from matching, betweem 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.

Further critique can be found 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 approach

2.1 The model before the financial intervention

To model the number of trees in a given region was propose 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 process can also be viewed as time changed BESQ (Bessel squared process). More precisely,

$$X(t) = e^{2\beta t}R\Big[\frac{1 - e^{2\beta t}}{2\beta}\Big]$$

where R is a BESQ with dimension 0 (or index -1).

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.

2.2 Financial Intervention.

In this section we will formulate an easy to solve optimization problem. We leave its solution and generalizations to another study, particularly, a dynamical approach, instead of our static one, would be more appropiate.

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

In the very first application, it could be dangerous to simultaneously sell good and bad (put) options.

We believe that the bank could manage this kind of market without any transaction costs. While selling good options the bank can choose optimal strike price k, and the price c, to maximize $\int_0^1 (X(s) \wedge k)ds$ which is the global goal!

Here k is the maximum capacity and $X(s)$ a diffusion process. Assuming linear utility, number of options is of no importance, so set this number=1.

To specify and simplify assume that $dX(s) = X(s)dW(s) + \beta X(s)ds$ with $X(0) = x_0$, which is an alternative model for the number of trees.

Assume that

She (the agent) will act in an optimal way, maximizing her linear utility with a final payment $A\int_0^1 (X(s) \wedge k - k_1)_+ ds$. This kind of payment is easier to handle then Asian options.

This is a only a static approach. 1 could mean one year and we set no interest rates.

Suppose that after her intervention the underlying asset will change into:

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

$$X(0) = x$$

Hopefully $B > \beta$, $x > x_0$.

Assume that the cost of her involvement, if worthy, is

$$c + c_1(x + x_0) + x_2(B - \beta)\int_0^1 (X(s) \wedge k)^p ds.$$

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 her linear utility can be expressed as

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

It is clear that there exists the global maximum to her utility G, and it can be found by taking derivatives with respect to x and B. After elementary calculations we obtain.

$$\frac{dg}{dx} = A\int_0^t e^{Bs}[\Phi(d_1^1) - \Phi(d_1)]ds - c_2(B - \beta)\int_0^1 e^{Bs}\Phi(d_1) - ds - c_1$$

$$\frac{dg}{dB} = A\int_0^1 sxe^{Bs}[\Phi(d_1^1)-\Phi(d_1)]ds - c_2(B-\beta)\int_0^1 sx\Phi(-d_1)ds$$
$$-c_2[k+\int_0^1 xe^{Bs}\Phi(-d_1)ds - \int_0^1 k\Phi(-d_2)ds]$$

where

$$d_1 = \frac{(B+\frac{1}{2})s+\ln x-\ln k}{\sqrt{s}}$$
$$d_1^1 = \frac{(B+\frac{1}{2})s+\ln x-\ln k_1}{\sqrt{s}}$$
$$d_2 = d_1-\sqrt{s}$$

Φ is the standard normal distribution function. 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 $A = \frac{\Sigma+c}{k}$ and therefore c is significant to solve the problem.

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 enviromentalists 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 of incompleteness. (Executive options can not 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:

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

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

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

Final Comments

So how do we roferest? This is a non trivial problem that we leave to a specialist. What should not happen is what occured after Kioto, when the Insurance Industry Iniciative stated that nothing can be done before an exact definition of for example reforestation is provided. in other words, it says "postpone the action forever".

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

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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