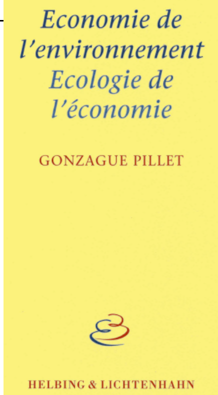
LECTURE 3 | A TECHNICAL MODEL OF POLLUTION ABATEMENT



LECTURE OBJECTIVES
This lecture will describe a model of pollution abatement that was developed from a non-economic perspective. Its foundation is in physics and it is particularly useful for engineers. The various elements of the model are individually described and then combined to find an equilibrium level of pollution abatement.

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Optimal pollution abatement, from an economic stand-point, occurs when the costs of abatement correct external costs (damage costs). Polluting economic activities will then end when *marginal* abatement costs equal *marginal* damage costs. Before this equilibrium is reached there is still an incentive to abate and beyond this point it will be more expensive to abate than to suffer the damages. The following model is a mixture of optimal pollution models and traditional approaches relating to the use of environmental property rights. The novelty of this model is that it stems from the area of physics and not economics.

1 | THE TECHNICAL MODEL: ELEMENTS AND MODEL SPECIFICATION

INTRODUCTION

The model developed by Borel underlines the fundamental relationships that exist between emissions, pollutant concentrations, the estimated costs of damages and the estimated costs of abatement (or, remediation). The underlying assumptions are that there is a single pollutant (or multiple pollutants grouped into a pollutant "basket" which is the usual method used when dealing with greenhouse gas emissions) in a well-defined and closed area.

The basic links and flows underlying the model are depicted in figure 1.

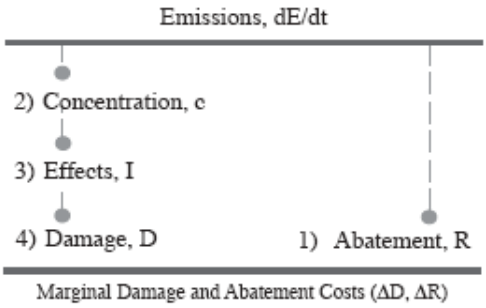

Figure 1 – The Technical Borel Model of Pollution Abatement

THE RELATIONSHIP BETWEEN EMISSIONS AND ABATEMENT COSTS

The relationship between emissions and abatement costs reflects the extra cost that results from a decline in emissions. The relationship is linear when situated between the technological minimum and the pollution tolerance maximum. Examining figure 2a below —

- dE/dt^{max} is the maximum discharge of the pollutant measured in the absence of any type of controls;
- dE/dt_l indicates the real or actual situation in the observed area with R_l representing associated expenses;
- dE/dt_{min} is the lowest possible amount of the emission consistent with the area's economic activities where R^{max} is the level of expenses associated with the technological maximum (from a treatment/remediation point of view).

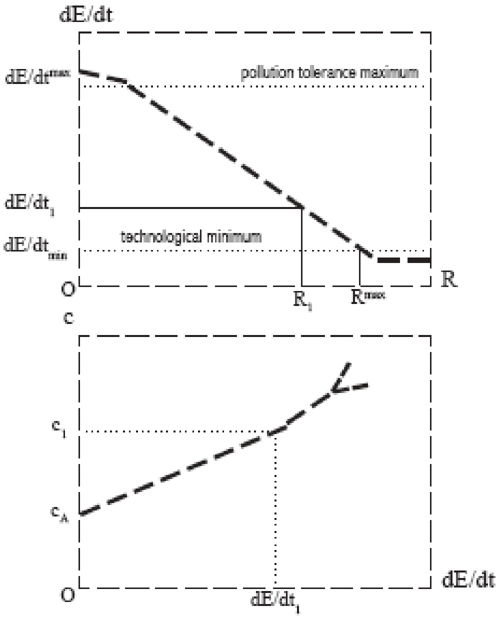

Figure 2a and b – Emissions | Abatement Costs and Emissions | Concentration Relationships

THE RELATIONSHIP BETWEEN EMISSIONS AND CONCENTRATION LEVELS

This relationship depends on how the pollutant is diffused into the environment. It can depend on a number of factors, such as meteorological conditions, wind patterns, or topography. In order to make the model more manageable, the average concentrations of the pollutant over long periods of time are used. Pollutant concentrations are as a consequence directly related to the rate of emissions.

Depending on the emissions that are observed, dE/dt_l (the rate of flow), an average concentration c_l is established (see figure 2b). This happens after the environment has assimilated the pollutant and/or when the pollutant has been exported and/or imported.

All of these factors depend on the pollutant's lifespan. For instance, mercury stocks accumulate and are never assimilated by the environment. In contrast, greenhouse gas emissions are to a certain extent absorbed by oceans and vegetation.

Point C_A corresponds to the concentration level of the pollutant that will be naturally absorbed by the environment, i.e. the natural concentration of the pollutant in question. For instance, current environmental policy objectives aim to stabilise countries' CO_2 emissions at 1990 levels. This is to avoid any further increase in emissions which would distort the planet's natural greenhouse effect. They also aim to push emissions closer to a natural concentration level.

CONCENTRATION LEVELS, THEIR EFFECTS AND THE DAMAGE CAUSED

The concentration levels of pollutants result in effects and impacts on the environment, humans and buildings. These are **dose-response** type effects and cannot yet be described as damages. Point C_o on figure 3 corresponds to the maximum dose of the pollutant before any type of impact is measured or effect is observed. The curve tends towards a maximum where for instance, the effect on vegetation would be the death of the plant (extreme or lethal impact). The second part of this flow is the translation of these effects into damages, or external costs expressed in dollars or in units that can be converted into dollars such as cubic meters of wood or number of days spent in hospital.

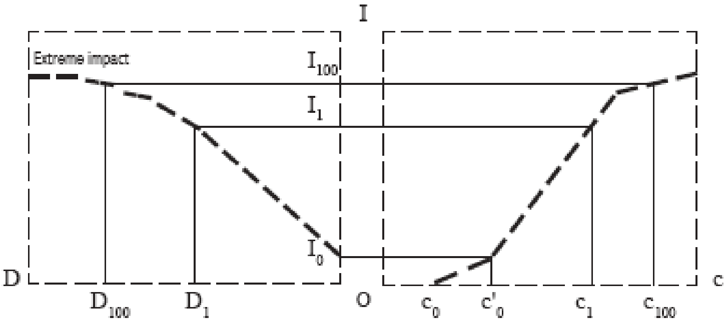

Figure 3 – Concentration | Effects | Damages Relationships

Point Io indicates the maximum effect that the environment can bear without any resulting external costs (for a concentration level c'$_o$). Point D_{100} corresponds to the maximum damages from an economic stand-point (e.g. lost harvests) but not necessarily an extreme impact (such as the death of a plant). Finally, external costs D_1 have an associated concentration level c_1.

2 | COMBINING VARIOUS ELEMENTS INTO ONE MODEL

All the previous figures have common axes and can consequently be combined to form a general model of damages and expenses (figure 4). From the first iteration results an increase in abatement costs from R_1 to R_2 and a fall in damages from D_1 to D_2. The difference between the increase in R and the fall in D indicates that the rise in abatement costs is largely compensated by the decrease in external costs.

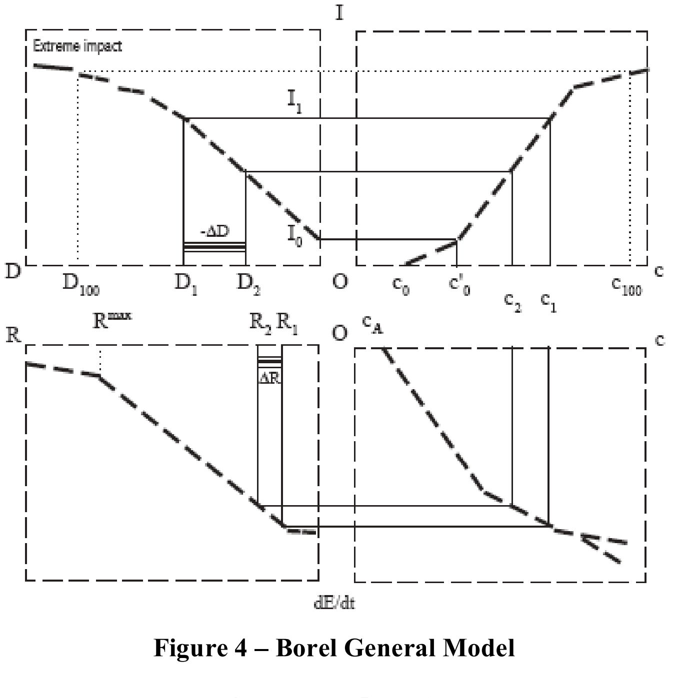

Figure 4 – Borel General Model

The iteration can also be carried out at R^{max}. This level corresponds to the technological maximum of pollution abatement. In effect, the iterative procedure will stop when, at the margin, the increase in costs is compensated by the fall in damages, in other words when costs and damages are equal, i.e. when $\Delta R = -\Delta D$. This is an equilibrium level of optimal pollution abatement.

SUMMARY

This lecture aimed to offer a different perspective regarding pollution abatement models and outlined a model developed from an engineer's point of view. The various elements of the model were detailed and combined to reach an equilibrium level of optimal pollution abatement. The next lecture will take a closer look at how to achieve this equilibrium and which instruments are more appropriate for different pollution regulation objectives.

ADDITIONAL REFERENCE

BOREL, R. (1975), *Unpublished manuscript*, Lausanne, Ecole Polytechnique Fédérale.