

## On the use of sensitivity analysis for a game-theoretic approach of environmental management problem

CHRISTOPHE DUTANG

*Univ. Grenoble Alpes, CNRS, Grenoble INP, LJK, Grenoble*

CLÉMENTINE PRIEUR

*Univ. Grenoble Alpes, CNRS, Inria, LJK, Grenoble*

Prioritizing environmental sustainability is a core strategy for securing the health and prosperity of modern societies. A good practice for a company to identify, manage, monitor and control its environmental impact is to use an environmental management system (EMS), such as the internationally recognized standard ISO 14001, based on environmental management problems proposed and solved by researchers. In the present work, we study the environmental management problem proposed by Haurie & Krawczyk [1] where they consider the pollution by multiple economic agents located along a river. An administrative authority aims to induce competing industrial agents to some sort of cooperation which would result in the satisfaction of the common environmental constraints.

To answer this question, Haurie & Krawczyk propose a (static) non-cooperative game which allows to set a Pigouvian tax for industrial agents in practice. Regarding non-cooperative games, two types of models have been considered in competitive markets: a) the Cournot oligopoly where industrial strategies are based on the choice of business volume and b) the Bertrand oligopoly where agents set prices. Haurie & Krawczyk assume industrial agents behave like the Cournot oligopolists where they set economic level  $x_j$  for  $j = 1, \dots, J$ . The equilibrium level  $x^*$  is a Nash equilibrium. That is, with payoff functions  $O_j$  and action set  $X_j$ , a Nash equilibrium is a vector  $x^* = (x_1^*, \dots, x_J^*)$  such that for all  $j = 1, \dots, J$ ,  $x_j^*$  solves the subproblem

$$\sup_{x_j \in X_j} O_j(x_j, x_{-j}^*),$$

where  $x_j$  and  $x_{-j}$  denote the action of player  $j$  and the other players' actions, respectively. The computation of equilibrium  $x^*$  for the model proposed by Haurie & Krawczyk relies on numerical methods, see [1].

For practical use of approach proposed by Haurie & Krawczyk, one must not only compute the equilibrium  $x^*$  but also measure how it is sensitive with respect to objective parameters  $O_j$ . For a three-player game with two levels of constraints, we count 18 parameters for which we want to understand the sensitivity. Using [2], we propose an in-depth analysis of the proposed game. We compare our approach with the current economics standard known as “comparative statics”.

### References:

- [1] Alain Haurie & Jacek B. Krawczyk, “Optimal charges on river effluent from lumped and distributed sources”, *Environmental Modeling and Assessment*, (2):177–189, 1997.
- [2] Saltelli, A., Ratto, M., Andres, T., Campolongo, F., Cariboni, J., Gatelli, D., Saisana, M. & Tarantola, S. (2008), “Global Sensitivity Analysis: the Primer”, *Wiley Interscience*.

[ Christophe Dutang; LJK ]

[ christophe.dutang@grenoble-inp.fr – <http://dutangc.free.fr> ]