Modelling Irreversibility in Human-Nature Interactions

João Rodrigues[1] , Tiago Domingos[2] and Pedro Conceição[3].

Economic growth models that study sustainability [1] make use of the concept of natural capital, which is viewed as a form of aggregate renewable resource. The dynamics of natural capital considered are usually very simplified, for example exponential or logistic.

In the present paper we model continuous irreversibility of human- nature interactions. We consider that human-nature interactions are composed by a *flow interference* that reduces the stock of natural capital and a *fund interference* that reduces the regeneration ability and the carrying capacity of natural capital [4].

These two forms of interference can be modelled as follows:

$$\begin{aligned} \frac{dN}{dt} &= f - P, \\ \frac{dCC}{dt} &= g - dist, \end{aligned}$$

where N is natural capital, CC is the carrying capacity of natural capital, f and g represent the endogenous dynamics of the natural system and P and $dist$ are, respectively, flow and fund interference. Continuous irreversibility is modelled because $dist$ can lead to an arbitrary decrease in CC.

Taking our motivation from [5] we follow [2] and [3], respectively, to specify the endogenous dynamics of N and CC as:

$$\begin{aligned} f &= r\,N\,(CC - N), \\ g &= \frac{l}{N+h}\,\frac{dN}{dt}, \end{aligned}$$

where r, l and h are constants.

We analyse this model from the point of view of biophysical sustainability. We conclude that it is sustainable to maintain flow interference, if it does not exceed natural regeneration, but that it is not sustainable to maintain fund interference.

[1]Secção de Ambiente e Energia – DEM, IST, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (e-mail: joao.rodrigues@ist.utl.pt).

[2]Secção de Ambiente e Energia – DEM, IST, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (e-mail: tdomingos@ist.utl.pt).

[3]IN+ (Center for Innovation, Technology and Policy Research), IST, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (e-mail: pedro.conceicao@undp.org).

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