

Ecological complexity in natural resource management modelling

Prof. Dr. Sylvie Geisendorf

ESCP Europe Business School Berlin

Heubnerweg 8-10

14059 Berlin

sgeisendorf@escpeurope.eu

Summary

The paper addresses the interdependency of economic activities and the ecological system. The natural system is more than an easy to understand boundary for the economy. It may transgress thresholds changing resource availability in a fundamental way. If the ecological dynamic is changing from its typical cyclic regime to an unstable chaotic behaviour, the production possibilities of the economic system are affected dramatically. Although we know from biology that ecological systems do not usually transgress that threshold by themselves, they may be pushed over the edge by economic influences. Only a careful depiction of how the ecological system reacts to influences from the economy will allow us to understand its impact on the economy. The paper elaborates step by step how we propose to model the ecological system and which influences from the economy we suggest to consider. We base our proposition for the ecological model on papers from biologists.

Abstract

The proposed paper addresses the interdependency of economic activities and the natural system. Ecological Economics has recognized the limits of optimal behaviour when faced with natural complexity. This led to the rediscovery of normative propositions, like a “save-minimum-standard”¹ or the “precautionary principle”² and Daly’s (1991) formulation of “management rules”. As far as the modelling of ecological-economic interactions is concerned, however, it took some years to go after a different kind of approaches³ and it is still not done sufficiently (Beretti et al., 2013).⁴

¹ Ciriacy-Wantrup, 1971

² Epstein, 1980

³ The few earlier Resource Economic models including restrictions to rational choice introduced a variance in the reproduction function, but still allowed profit optimization (e.g. Charles, 1983 or Reed 1979).

⁴ Somemore elaborate models exist. However, with a few exemptions, most ecological-economic models fall into one of two categories. They either propose a complex ecological part but combine it with the standard economic optimization approach, or they offer an elaborate description of economic complexity combined with a simple link to a resource equation. Only a few, like Janssen and de Vries (1998), Little and McDonald (2007), Schlüter and Pahl-Wostl (2007), Noailly (2008), Nannen and van den Bergh (2010) and Klarl (2013) give a better account of the complexity of both systems.

Recognizing the limits of optimal behaviour when faced with natural complexity has two consequences for ecological-economic modelling. 1. human behaviour should be modelled as being bounded rational, and 2. the natural system has to be depicted in its actual complexity. The current paper concentrates on this second aspect. It is part of a larger research project in which we try to integrate both aspects, yet this paper proposition for the ESEE conference focuses on the ecological part of our model because it is complex enough and needs some discussion.

The ecological system is more than an easy to understand boundary for the economic system. It may transgress thresholds changing resource availability in a fundamental way. If ecologic dynamic is changing from a stable fixed point or cyclic regime to an unstable chaotic behaviour the production possibilities of the economic system are affected dramatically. On the other hand, we know from biology that ecological systems do not usually transgress the threshold to chaotic behaviour by themselves. They may, however, be pushed over the edge by economic influences (Berryman et al, 1989; Turchin and Ellner, 2000; Scheuring, 2001). This makes it all the more obvious why the link between the two systems has to be modelled more carefully and considering more than the standard extraction or harvest term. Only a careful depiction of how the ecological system may behave in interaction with the economy will allow us to understand its impact on the economic evolution.

The paper elaborates step by step how we propose to model the ecological system and which influences from the economic system we suggest to consider. The ecological model is based on papers from biologists and follows their arguments on why certain modelling decisions should be taken.⁵ In particular, we explain why we think a viable ecological part of an ecological-economic model should be a discrete time model with the potential to be in fixed-point, cyclic and chaotic regimes, where the later can be triggered by the interaction with the economic system (Berryman et al., 1989). More specifically, the economy is able to – either deliberately or accidentally – increase the growth rate of a natural species and induce delays in the regulatory negative feedback. This could lead to the phenomenon of overshooting (i.e. increase) of a population over its carrying capacity with the subsequent effect of lowering the carrying capacity (Radzicki & Taylor 1997) and ultimately push a natural system into unstable behaviour.

Depicting such more complex dynamics in the interaction of nature with the economy requires two things. First, the natural system has to be modelled in a way enabling such dynamics – which neoclassical resource or environmental economic models usually do not. And second, the economic influence on nature has to be modelled by more than just extraction (in resource economic models) or pollution (in environmental economic models).⁶ Only a combination of both influences plus possible further impacts, like e.g. growth

⁵ May, 1973; Berryman et al., 1989; Scheuring, 2001; Domokos and Szász, 2003; Domokos and Scheuring, 2004

⁶ A notable exemption considering both aspects is Xepapadeas (2009) who introduced a second influence on the natural system besides extraction and suggested that it may affect the growth rate as well as the carrying capacity.

enhancing fertilizer or the decimation of a natural pest or predator allows us to understand the real complexity of the ecological-economic interaction. The paper explains how this could be achieved by formulating an appropriate model for the natural system and the essential links to the economic system.

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