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Waste production and regional growth of marine activities an econometric model

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ABSTRACT

Coastal regions are characterized by intense human activity and climatic pressures, often intensified by competing interests in the use of marine waters. To assess the effect of public spending on the regional economy, an econometric model is here proposed. Not only are the regional investment and the climatic risks included in the model, but also variables related to the anthropogenic pressure, such as population, economic activities and waste production. Feedback effects of economic and demographic expansion on the pollution of coastal areas are also considered. It is found that dangerous waste increases with growing shipping and transportation activities and with growing population density in non-touristic coastal areas. On the other hand, the amount of non-dangerous wastes increases with marine mining, defense and offshore energy production activities. However, lower waste production occurs in areas where aquaculture and touristic industry are more exploited, and accompanied by increasing regional investment in waste disposal.

1. Introduction

Anthropogenic pressures on marine resources, the demand for ecosystem services, such as tourism and business recreation, are often too high and spread on a global scale. Therefore, not only the European Union has implemented and brought to public attention the importance of these pressures on the environment (Directives 2000/60/EC and 2008/56/EC), but also the scientific community has demonstrated the need to mitigate those impacts and demands, for providing ecosystem services, human health protection and the preservation of the environmental assets.

The Water Framework Directive (WFD) 2000/60/EC is the first legislative act that introduces the concept of "ecological status" of a water body which is related with the planning of interventions and protection to maintain or achieve "good ecological status". Thus, the WFD requires the adoption of adequate classification criteria based on Biological Quality Elements (BQEs) characterizing water bodies, including coastal waters. Moreover, the WFD recommends that the boundaries of the classification criteria of the ecological status are defined using metrics sensitive to pressures.

With the Marine Strategy Framework Directive 2008/56/EC, the European Union (EU) recently promoted the application of an ecosystem approach to the management of the economic activities related to the sea. This approach provides precise information on the *quantification* of marine biodiversity in relation to the functioning of ecosystems (see Boero and Bonsdorff, 2007), on his *conservation* in time and space, and on the close link between marine biodiversity and the production of ecosystem services, the evaluation of which is to date very complex and not easily definable.

Sporadic though effective measures for the enhancement of specific activities related to the use of marine resources might often have negative side effects on the conservation and protection of marine biodiversity, or on other ecosystems which are located even at great distances.

Coastal areas attract a variety of interests and activities with respect to very specific areas of the regional hinterland. Given that coastlines are characterized by a limited space due to the topography and by intense climate action, they often represent the place where environmental and socio-economic pressures interact.

Therefore, different economic actors are often involved in a confrontation with Institutions and the resident population for the use of coastal and marine resources. Economic activities such as the production of hydroelectric power, ports and related services, marinas, desalination plants, sewage treatment plants and waste water management and so on, are locally and inextricably linked to coastal areas. These economic activities impact the environment by generating a deterioration or even a degradation of coastal ecosystems (IPCC, 2012) and are often in conflict with the activities of tourism and protection of biodiversity. This degradation of the marine ecosystem is often aggravated by increasingly frequent floods and intense coastal erosion due to the ongoing climate change (Adger, 2006).

Hence the importance of a tool for regional policies to support decisions related to resource management, regional socio-economic growth, environmental risks generated by human activity and the effects of climate change. The Integrated approach to Coastal Zone Management (ICZM) provides policymakers with regional integrated

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objectives and tools for the sustainable development of coastal areas (Fabbri, 1998).

However, a prerequisite to the integrated management of coastal areas is not only the knowledge of the topography and socio-economic areas of interest, but also the effectiveness of regional investment to stimulate the economic growth on the one hand, and to mitigate negative externalities on the other hand, through the protection and preservation of the marine environment.

The main objective of this study is to provide a tool for evaluating the effects of regional policies on the development of economic activities related to the use of the sea and the impact on the marine environment due to pollution and the effect of climate change.

To this aim, an econometric model is estimated using regional data and then employed for simulating the impact of various scenarios of regional investment policies on the growth of the Blue Economy and on the marine environment. Ultimately, the model helps to assess the effectiveness of measures taken to stimulate sustainable economic growth in coastal areas.

2. Literature

Unlike physical systems, which allow for the use of controlled experiments, the response of the economy to the deterioration of resources and climate change does not allow for replicating experiments and therefore it requires the use of models.

This represents a challenging task for a number of reasons. Because of the uncertainty of climate, which is amplified by the uncertainty on how individuals, businesses and governments respond to its changes through action on ecosystems.

Temperature, precipitation, sea level rise and the erosion of coastlines are the main climatic factors affecting the human well-being, directly or indirectly, through socio-economic and ecological impact.

Thus, the Global Climate Models (GCMs) provide estimates of the main variables of interest, precipitation and temperature, with high temporal and spatial resolution. However, much uncertainty remains on the assumed distributions.

In UNESCO (2002) several case studies related to coastal regions and islands are analyzed using a qualitative approach in order to provide countries with guidelines and best practices for the prevention and resolution of conflicts arising from the use of coastal resources. From an environmental perspective, other case studies are presented in Nicholls et al. (2008), concerning the exposure and vulnerability of coastal cities to climate extremes. Fulanda et al. (2011) considers conflicts between residents and fishermen in the Ungwana Bay (Kenya) using a surplus production model to assess the dynamics of resource-use management.

From the theoretical point of view, there are several contributions to the modeling of resource use and externalities in various fields of ecology, economics, and socio-political and environmental studies.

Jouvet et al. (2007) considers the impact of environmental quality on the longevity and well-being of the population through an overlapping generations model. One of the most interesting approaches to the scarcity of resources and their competing use is in Homer-Dixon (1994), which studies the environmental scarcity (climatic deterioration, loss of fertile land, forest degradation, reduction of water supply, pollution) and the population growth in situations of social inequality in the distribution of resources. This socio-political approach suggests that both total and per capita renewable resources are key factors in explaining the anthropogenic pressures on the environment, but what really matters is their distribution and concentration over the population.

Homer-Dixon (1994) proposes two models that suggest two types of causality between factors of the scarcity of resources. The first model is the *resource capture*, where resource depletion and population growth cause unequal access to resources. The second model is the *ecological marginalization*, which emphasizes that the unequal access to resources and population growth are causing, in turn, degradation and resource depletion. Therefore, these two causal links can be seen together in a cyclic structure in which the cause becomes effect and vice versa.

Brugère (2006) states that the conflicts between economic actors are not only the result of a competition for the use of resources, but above all the result of a failure of the institutions. In particular, he demonstrates, using the case study of India on aquaculture, that the ICZM in developing countries is not effective because of institutional inefficiency. Hence, our research focuses on the effectiveness of regional policies on the economic growth on the one hand, and on the conservation and protection of environmental assets, on the other hand.

In relation to the issues of environmental ethics, Turner (1993) introduces different categories of sustainability, ranging from *weak* environmental sustainability, where the natural capital is replaced by capital *manufactured*, to *strong* sustainability, which rejects all forms of substitutability, meaning that all the natural capital must be protected and preserved. Ekins et al. (2003) suggest an approach to strong sustainability, justified by some fundamental differences between *manufactured* and *natural* capital, related to the reproducibility of the first and the irreversibility in the consumption of the second.

A recent strand of literature has defined the concept of ecological *critical natural capital*, as part of the natural capital that cannot be replaced by other types of capital (see Turner, 1993; de Groot et al., 2003), thus reducing the gap between the weak and strong concepts of environmental sustainability.

In Ekins et al. (2003), the concept of natural capital is based on its complementarity or substitutability with respect to the manufactured capital, especially when the latter comes from the institutional intervention, under the form of public good as *substitute* to the environment. In this way, the provision of public goods could be a solution to offset the deterioration of natural capital, as proposed in Acocella et al. (2013).

From the quantitative point of view, different classes of models are used to assess the effects of public spending.

The statistical-econometric models are used to estimate the costs-benefits of using natural resources, such as marine resources, and the action of the climate. Among the advantages of the econometric approach, there is the use of observed data. On the other hand, as these studies deal with specific regional or lower level of spatial aggregation, they are very often used to obtain estimates of global impact.

In addition, these models are sensitive to the estimation technique and the choice of variables used to explain changes in costs and benefits.

An alternative to modeling the potential economic damage of the use of environmental resources and climate change is the use of simulation models on a large scale. This approach of computable general equilibrium (CGE) is based on the representation of the different sectors of the global economy, and requires specific assumptions on the economic sectors of interest. In those models all sectors are interrelated: damages caused by the use of resources may affect the labor market in the agricultural sector, which in turn affects the wages in agriculture and potentially other sectors. Some of these simulation models are constructed under the assumption that economic growth is directly linked to the amount of pollutants released into the air, water and soil.

Through a system of feedbacks, the environmental damage in the model depends on waste and emissions, which in turn depend on the economic activity. While the advantage of these simulation models lies in their ability to represent the spillover effects between sectors and the feedback between the economy and the ecosystem, their main disadvantage is that they need assumptions not only on the links between the sectors of the economy, but also on the response to the pressure of human activity and climate. The results of the econometric studies could ideally be used to parameterize the CGE simulation models, but in practice it is rarely possible because the required number of parameters in the CGE models is much bigger than what the econometric models can provide. Simulation models have the fundamental advantage to simulate the impacts of different policy instruments in the field of environmental protection and conservation, as well as for the economy as a whole.

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