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Emerging megaregions: A new spatial scale to explore urban sustainability

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ABSTRACT

This paper aims to better understand the environmental implications of a new economic unit of analysis consisting of networks of cities called megaregions. We have tested the working hypothesis according to which those regions (European NUTS3) belonging to a megaregion present benefits of economic productivity (growth of GDP per capita) compared to regions that have not been incorporated into a megaregion or have done so recently. A multiple linear regression analysis has established significant relationships between economic, urban and ecological variables: the formation of networks of cities enables economies to concentrate knowledge, achieve greater efficiency in resource consumption (energy), higher productivity (GDP) and lower entropy (less CO_2 emissions, better functional structure of the landscape). This pattern of relationships appears both statistically robust and sensitive at the time of incorporation of the European regions (NUTS3) into megaregions. This work contributes to the debate on the essential properties of a regional economy optimizing environmental performance at the level of the megaregion.

Introduction

Margalef (1968) helped establish the theoretical foundation for understanding that the sustainability of development is a direct function of complexity, and a reverse function of energy dissipation (entropy). When the increase of the entropy decreases the system's complexity, environmental degradation is a tangible result of an unsustainable development strategy (Ulanowicz, 1997).

In regional environmental policy there is the usual trade-off between economic development and environmental quality (Batabyal and Nijkamp, 2009). In this paper we aim to show some evidence that it is possible to combine both objectives. Large urban agglomerations could rely on economic models more based on knowledge than on consumption of resources: this is the challenge of sustainability.

Night-time light (NTL) data allows us to analyze, on a global scale, the evolution of networks of cities towards structures that already exceed the metropolitan scale (Doll, 2008; Zhang and Seto, 2011), systems that are called "megaregions". Megaregions are emerging global economic units, the result of the concentration of production facilities, innovation and consumer markets (Florida et al., 2007). Their development is based on socioeconomic dynamics, processes that cause profound changes on their environment and, in turn, accelerate global change (Grazi et al., 2008).

The complexity in the landscape appears inevitable due to the dissipation of energy in space (Pulselli et al., 2006), resulting in the construction of organized structures (Morowitz, 2002). The development of the city in a landscape matrix is no stranger to this dissipative process (Filchakova et al., 2007) resulting in increasing complexity inherent in its own urban metabolism (Wilson, 2009).

The demand for land to accommodate housing, economic activity, infrastructures and transport networks produces a significant pressure on the environment (Williams et al., 2000). Moreover, urban sprawl has been poorly managed (Breheny, 1992), which has led serious problems in quality of life and the ecological functioning of the landscape.

There are many studies of urban ecology at local level (Rickwood et al., 2008), and the effects of urban growth on the landscape on a metropolitan and regional scale (Marull et al., 2010). However, these studies do not take into account a new reality, the formation of networks of cities on the scale of a megaregion.

Applications developed on the basis NTL data framed by artificial satellites (Doll, 2008), allow us to define urban extensions, calculate energy consumption, estimate economic activity, and model emissions of greenhouse gases at the level of megaregions. Moreover, we analyzed the economic efficiency of the network of cities that make up megaregions, and their effects on ecological processes taking place in the landscape.

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This paper departs from the question whether these concentrations of activity in expanding urban areas can contribute or not to the sustainability of our European societies, that is, if megaregions should be considered as a problem or a potential solution for a more sustainable economic growth.

The hypothesis is that megaregions have emerged along with greater dissipation of energy and with the establishment of networks of cities that are more efficient in their economic activity and knowledge creation, suggesting the need for a new geographic scale to explore sustainability. In short, the object of this paper is to approach the development of towns and cities towards more complex urban systems called megaregions, and analyze the consequences of this new geographic scale in the context of sustainability.

In order to develop this analysis we firstly test the working hypothesis that the inclusion of a European region in a megaregion implies benefits in terms of economic performance; secondly, we analyzed through a regression analysis the relationships between economic, urban and ecological variables in European regions, considering that some of them pertain to a megaregion.

From networks of cities to megaregions: the unit of analysis

Cities are not isolated systems, but are connected together to form networks. Traditionally, urban systems have been studied from a hierarchical point of view (Christaller, 1933). According to this view, the urban dimensions would reflect the existence of a hierarchy of goods and services, which would express the size of the market. However, later studies have shown that some urban structures are a mix of hierarchical (vertical) and non-hierarchical (horizontal) structures, in the form of "networks of cities" (Pred, 1977; Boix and Trullén, 2007). Networks of cities have been defined as a set of relationships between complementary or similar centres, relationships that allow the emergence of economies of specialization (division of labour) or the formation of economies of synergy (cooperation and innovation) (Pred, 1977; Camagni, 2005). In these networks, cities benefit from economic advantages stemming not only from their own dimension, but also from the size of the whole network. So, the paradigm of networks of cities implicitly suggests extending the scope of analysis beyond the metropolitan area. The importance of this scaling is critical to help achieve positive results in terms of economic efficiency and, probably, environmental sustainability.

Megaregions have been defined as networks of metropolitan areas and their surrounding areas (Florida et al., 2007; Ross, 2009). They represent a new economic unit of analysis that emerges to the extent that metropolitan regions not only grow upwards and become denser, but also grow outward, encompassing one another. Consequently, a megaregion is a polycentric expanding network.

The key factor in megaregional development is that growth does not start from a central agglomeration towards an empty area but can instead encompass many other smaller urban areas and also some of a similar size to the central one. Therefore, typically urban agglomeration economies can be achieved, such as economies stemming from concentrated and diversified economic (and social) structure, and economies fed by the relationships that are developed in the network of cities that constitute the megaregion (network economies). Thus, the study of economic growth and wealth creation, and other social and natural phenomena (pollution, landscape changes), performed only through data from the city or country can be misleading.

Sustainability at the level of megaregions

One might think that the enormous agglomeration of people and economic activities involving the formation of megaregions would lead to serious environmental problems that might compromise their own development and existence (Banerjee, 2009). Some systems with more urban population may be groups of cities where innovation and wealth creation per capita are higher than in smaller agglomerations (Bettencourt et al., 2007). Here we pose the question if these systems can also be more sustainable.

Previous work on sustainability at the level of megaregions has mainly focused on defining the concept of megaregions, and asking how the recognition of this new geographical scale can help improve aspects of urban and global competitiveness, social equity and territorial identity (Ross, 2009). Although the concept of megaregion seems to be focused on economic growth, a sustainable megaregion can also be defined as one in which there are forms of economic development that allow improvement to people's welfare, reduction in energy consumption and preservation of ecosystems quality (Wheeler, 2009). Therefore, the treatment of the challenges megaregions pose will include key issues such as management of urban growth and population, improvement of environmental quality, transport infrastructure and mobility, reduction of greenhouse gas emissions, and governance and social equity issues (Dewar and Epstein, 2007; Benner and Pastor, 2011).

The megaregional approach has been considered as an effective scale for environmental management (Wheeler, 2009), including its ability to preserve large ecological systems (watersheds, natural habitats, etc.) and therefore allow the integrated management of these systems within a coherent spatial planning framework (Regional Plan Association, 2006). Implicitly, we consider the fact that megaregions become the new units in the competitive global economy could indirectly benefit the environment. Moreover, the polycentrism that accompanies the development of megaregions and the consequent investment in transport infrastructure can help to contain some of the problems of economic and urban development (Yusuf, 2007). Concentration of future growth following a higher density and with mixed use along infrastructure corridors or nodes remains a preferred scenario for the smart growth that new urbanism advocates (Banerjee, 2009). Ross (2009) defends that the implementation of climate change strategies and programmes to minimize risks is more appropriately advanced under the framework of the megaregion. However, other authors argue that if future urban development becomes more sustainable in environmental terms it will not be the result of the approach provided by megaregions (or any alternative scale), but will be directly linked to social commitment and specific compensation between economic development and environmental conservation (Campbell, 2009). We have not found previous work at the level of megaregion that provides a picture of sustainability in its broadest sense (economic, environmental and social) and its evolution over time. Some studies have tried to define and characterize the global megaregions in North America and Europe, but do not incorporate the environmental dimension (Gottman, 1969; Lang and Dhavale, 2005; Florida et al., 2007). Graymore et al. (2008) evaluated the effectiveness of sustainability assessment methods on the regional scale and found that they failed to measure progress towards sustainability, demonstrating the need for a new methodology. Several papers describe sustainability at the regional level using aggregate indicators such as the ecological footprint (Wood and Garnett, 2010), but do not scale megaregionally. Other interesting approach is based in accounting the socio-metabolic flows of cities and their hinterlands (Billen et al., 2012).

In the present work, we use the case of the European regions to approach the development of cities and metropolis to more complex urban systems, in order to analyze its implications in relation to sustainability at the megaregional scale. It is important to remark that in order to measure sustainability we do not take into account all the indirect impacts the megaregion has on environment and