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Sustainability of the energy sector in the Mediterranean region

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ABSTRACT

Energy and climate change is a key priority issue mentioned by the Mediterranean Strategy for Sustainable Development (MSSD) which explicitly claims that "Control, reduce or stabilize GhG (Greenhouse Gas) emissions" is a crucial target for Mediterranean countries. This paper uses the integrated assessment model IFs (International Futures) to implement a scenario analysis to investigate the mitigation potential of Mediterranean regions. It analyzes if the Mediterranean regions will be able to reach the MSSD climate change target and recommends amendments of the MSSD to implement with effectiveness climate change policies in the Mediterranean area.

1. Introduction

At the 12th meeting of the Parties the Contracting Parties of the Barcelona Convention decided to prepare a Mediterranean Strategy for Sustainable Development (MSSD). The MSSD (UNEP/MAP [1]) is a framework strategy which aims to adapt international commitments to regional conditions, to guide national sustainable development strategies and to initiate a dynamic partnership amongst countries party to the Convention. The Strategy aims to promote sustainable development which includes progress in economic, social and environmental areas as well as in governance. The Strategy is organized into 7 different priorities and 4 objectives as showed by the Table 1.

This paper will just investigate the "Energy and climate change" priority with a specific focus on the "Sustainable economy and management of natural resources" objective and in particular the MSSD target "Control, reduce or stabilize GhG emissions". The aim of the paper is answering the following questions:

1) Are the Mediterranean countries reaching the MSSD climate change target to stabilize emissions by 2015?
2) What are the policy implications of the current path of Mediterranean emissions?

The climate change economics literature is full of examples where scholars analyse the effects of specific policies such as carbon pricing systems (Bosetti et al. [2], Cantore and Padilla 2010 [3]) or the impact of different scenarios (Akashi et al. [4], Pao et al. [5]). A novelty of this paper is that it deals with the impact of a regional strategy where specific national policies are not prescribed in detail, but are left to the sovereignty of single countries. A regional strategy is justified by the peculiar homogeneity of Mediterranean countries in terms of environmental and climate change impacts on marine ecosystem, coastal management, fishing etc. and by the need to create a coordinated set of actions to tackle shared problems. A regional strategy for sustainable development is very innovative in the world environment policy and this paper trying to explore which policies or factors can contribute mostly to reach the targets contained in the Mediterranean Strategy is original in the current literature.

Many studies exist about the link between climate change and the Mediterranean region, but they deal in many cases with climate change projections (Giorgi and Lionello [6]) or the impacts of climate change (Iglesias et al. [7]). To the best of knowledge this is the first attempt in the literature to study a regional Mediterranean mitigation target. This is partly because the Mediterranean region is not a legal entity entitled to negotiate emissions reducing international agreements. However the existence of a Mediterranean Strategy for Sustainable Development agreed by Mediterranean countries and prescribing an emissions path within 2015 justifies

Abbreviations: BOE, barrels of oil equivalent; C, carbon; EEA, European Environment Agency; EE, energy efficiency scenario; GhG, greenhouse gas emissions; MAP, Mediterranean action plan; MDGs, millennium development goals; MSSD, Mediterranean strategy for sustainable development; RE, renewable energy scenario; REC, recovery scenario; t, tons; UNEP, United Nations environment programme.

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the research need about mitigation policies in this region. An implementation of MSSD can be successful if appropriate research can help to inform policy makers on how policies or factors such as growth and technological change can provide an impact on climate change emissions. This paper is aimed at filling this gap.

The analysis focuses on scenarios implemented through the International Futures model of the Pardee Institute for International Futures (Hughes [8], Moyer and Hughes [9]). IFs is a model containing blocks of equations describing the economies of 183 countries. Even though the climate change economics literature contains studies implemented with a wide variety of integrated assessment models (e.g. Keppo and Strubegger [10] and Kemfert C [11].), the detailed IFs model structure (Fig. 1) allows to fully analyse in detail the Mediterranean region and single sub/regions or countries. The model is structured in order to allow the analyst to play with the path of relevant economic, social and environmental variables by changing the values of the relative coefficients. The next paragraph contains a quick description of the model and scenarios. The paragraph 3 discusses results. The final paragraph contains conclusions.

2. Model, scenarios and IFs baseline

The great advantage in using IFs is that integrated assessment models encourage a deep investigation of the economic, environmental and social sustainability determinants. Scenario analyses are run by assuming different paths over time of relevant parameters. The wide mass of information contained in IFs also allows to analyse in detail issues related specifically to the Mediterranean region.

In the energy/environment module, the global annual emissions depend on the total production of fossil fuel sources of energy (oil gas and coal) and expressed as follows:

$$\mathrm{CARANN}_t = \mathrm{WENP}_{\mathrm{oil},t}{*}\mathrm{coeff1} + \mathrm{WENP}_{\mathrm{gas},t}{*}\mathrm{coeff2} + \mathrm{WENP}_{\mathrm{coal},t}{*}\mathrm{coeff3} \quad (1)$$

where t is time, WENP_i i = oil, gas and coal is world energy production, coeff1, coeff2 and coeff3 are coefficients expressing the quantity of emissions per ton of fossil fuel production. The model includes the production of both fossil fuel and fossil free (nuclear, renewable, hydroelectric) sources of energy. The full set of energy sources including fossil and non fossil energy is represented by the label j.

The supply equation for energy is very simple and expressed by the Eq. (2):

$$\mathrm{ENP}_{r,j,t} = \frac{\mathrm{KEN}_{r,j,t}}{\mathrm{QE}_{r,j,t}{*}\mathrm{qem}_{r,j,t}}{*}\mathrm{enpm}_{r,j,t}{*}\mathrm{CpUtf}_{r,j,t} \quad (2)$$

where r is the country, ENP is Energy national production, KEN is invested capital, QE is a capital/energy production ratio and qem is a parameter representing technological change (capital/energy production reduction), CpUtf is a parameter representing constraints in the capacity utilization factor, enpm is a parameter representing exogenous shifts of energy production. Once production is computed it is possible to calculate a world average price (WEP), weighted by energy production (ENP) in each category and each region.

$$\mathrm{WEP}_t = \frac{\sum_r^r \sum_j^j \mathrm{ENP}_{r,j,t}{*}\mathrm{ENPRI}_{r,t-1}}{\sum_r^r \sum_j^j \mathrm{ENP}_{r,j,t}} \quad (3)$$

where WEP is the world energy price, ENPRI is the regional energy price. ENPRI is determined by the following equation:

$$\mathrm{ENPRI}_{r,t} = \mathrm{ENPRI}_{r,t-1}{*}\frac{\mathrm{WCOST}_t}{\mathrm{WCOST}_{t-1}}{*}\mathrm{markup}_{r,t} + \mathrm{encartpp}_r \quad (4)$$

where WCOST is the world production cost per unit of production, mark up is a regional specific factor depending on inventories and stocks, encartpp is a region specific parameter. WCOST depends on the following equation:

$$\mathrm{WCOST}_t = \frac{\sum_r^r \sum_j^j \mathrm{KEN}_{r,j,t}}{\sum_r^r \sum_j^j \mathrm{ENP}_{r,j,t}} \quad (5)$$

The global energy market is a highly integrated one. IFs computes only aggregated regional or national energy demands and prices, however, on the assumption of high levels of long-term substitutability across energy types and a highly integrated market. The model also conducts energy trade only in a single, combined energy category. The aggregated energy demand for all sources of energy is determined by the following equation:

$$\mathrm{ENDEM}_{r,t} = \mathrm{BENDEM}_{r,t}{*}\left(1 + \frac{\mathrm{crtaxd}_{r,t} + \mathrm{WEP}_{t-1} - \mathrm{ENPRI}_{r,t=1}}{\mathrm{ENPRI}_{r,t=1}}{*}\mathrm{ELASDE}_r\right){*}\mathrm{ENDEMM}_{r,t} \quad (6)$$

where ENDEM is final energy demand, crtaxd is the increase of energy price generated by a carbon tax, ELASDE is a parameter representing the responsiveness of energy demand to prices, ENDEMM is an exogenous parameter, BENDEM is an initial energy demand variable calculated as follows:

$$\mathrm{BENDEM}_{r,t} = \mathrm{GDP}_{r,t-1}{*}(1 + \mathrm{GDPR}_{r,t-1}){*}\mathrm{ENDK}_{r,t}{*}\mathrm{ENDM}_{r,t} \quad (7)$$

where GDP is gross domestic product, GDPR is the growth rate of GDP, ENDK is a coefficient expressing the energy required for each unit of GDP and ENDM is an internal adjustment multiplier. GDP is determined by the following equation:

$$\mathrm{GDP}_{r,s,t} = f\left(K_{r,s,t} L_{r,s,t} \mathrm{MFP}_{r,s,t}\right) \quad (8)$$

where K_s is sector specific capital, L_s is sector specific labour, $\mathrm{MFP}_{r,s}$ is multifactor productivity and MFP depends on variables as specified by the following equation:

$$\mathrm{MFP}_{r,s,t} = f\left(\mathrm{Knowterm}_{r,s,t}, \mathrm{hcapterm}_{r,s,t}, \mathrm{socialcapterm}_{r,s,t}, \mathrm{phcapterm}_{r,s,t}, \mathrm{mfpadd}_{r,s,t}\right) \quad (9)$$

where knowterm is related to variables such as R&D, innovation etc., hcapterm is related to human capital, socialcapterm is related to economic integration, phcapterm is a term related to the devaluation of the capital stock deriving from the increase of energy prices, mfpadd is an exogenous parameter representing economy productivity long run growth. Crtaxd is determined by the following equation:

$$\mathrm{crtaxd}_{r,t} = \frac{\sum_{i=1}^3 \mathrm{crtaxrev}_{r,i,t}}{\sum_{i=1}^3 \mathrm{ENP}_{r,i,t}} \quad (10)$$

where crtaxrev is the total revenue from carbon tax. A carbon tax affects the supply by decreasing profitability of investments for carbon fuel sources of energy which is contained in the following equation:

$$\mathrm{INEED}_{r,j,t} = \mathrm{KEN}_{r,j,t}{*}\frac{\mathrm{INEED}_{r,j,t-1}}{\mathrm{KEN}_{r,j,t-1}}{*}\left(\frac{\mathrm{eprofits}_{r,j,t}}{\mathrm{eprofits}_{r,j,t-1}}\right)^{\mathrm{elas}} \quad (11)$$