Environmental and energy efficiency analysis of EU electricity industry: An almost spatial two stages DEA approach.

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Executive Summary

The analysis of the dynamics of Environmental and Energy Efficiency (hereafter EEE) is attracting growing attention in recent years since innovation and diffusion of more energy-efficient technologies is a key factor of the EU 2030 Climate and Energy Strategy to make carbon free power generation and increase the energy performance of national system.

EEE is a crucial key in the transformation sector to make carbon free power generation. Internal and external factors are changing the traditionally largely asset-based industry moving to a new and more complex decentralized generation system. Internal factors refer to technological changes and to the fuel energy mix that deeply changed in EU countries also due to the widened spread of renewable energy sources (RES), while external factors involve policy and regulatory interventions, changes in consumers' preferences and environmental attitude.

The paper intends to measure the technical EEE of EU electricity industries taking into account: i) greenhouse gas emissions as "bad" output from electricity generation; ii) the impact of sector and environmental regulation; iii) the spatial component in technical efficiency explanation.

The methodological approach is based on a two stage strategy. In the first stage, we measure the environmental energy efficiency in electricity industry using the Malmquist Index (MI) of Total

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factor productivity (TFP); we then decomposed MI in its three main components representing the different sources of efficiency: the shift of technological frontier, the scale efficiency and the pure efficiency terms. In the second stage, we apply a dynamic panel data analysis, regressing the measures of efficiency derived in the first stage on the sector and environmental regulation indicators (OECD indicators) and on the spatial contiguity indicator. Paper highlights that EEE is a stable dynamic process in which larger variations in the lagged period favor lower variations in TFP in the next period, justifying our choice of dynamic panel data model.

The analysis develops an appropriate framework able to capture the complex interplay between the policy instruments available and how their effects in EEE are not univocal.

In particular, the stringency of sector regulation has significant and negative effect on both the overall and the disaggregated measures of performance and it may reduce total factor productivity from 7.4% to 8.5%. The stringency of environmental regulation has instead no significant effect in the overall performance. However, decomposing the aggregated MI index, the single scale efficiency measure is positively encouraged by the stringency of market-based environmental policy instruments. The impact of spatial contiguity on the overall efficiency index is significant and positive showing how the grid interconnection spurs efficiency in electricity sector.

Results disclose the increasing complexity of the policy interventions to trigger sustainable technical efficiency and the latent tensions among the different dimensions of the country-specific institutional settings.

Keywords: electricity, total factor productivity growth, undesirable output, market and environmental regulation, spatial effect.