Heterogeneous Returns to Scale of Wind Farms in Northern Europe

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Executive summary

The deployment of renewable resources is a priority of the global energy agenda. The move toward a more sustainable energy mix requires investments in wind energy.

The industry presents two different economies-of-scale. The economies-of-scale of a single turbine and the economies-of-scale of an entire farm. The power of a turbine is function of its height and of the size of the rotors. However, given that each turbine generates a wake effect which affects all the nearby installations, it is impossible to put many big turbines close to each other in windy areas. Therefore, the optimal layout of a farm faces a critical trade-off: either few tall turbines or many small ones.

The present paper aims to present a single production function for off-shore and on-shore platforms able to captures per-turbine returns on the amount of installed capacity. We identify the farm size which can extract the highest amount of MWs per turbine for the Northern European region using a Varying Coefficient Model (VCM) specifically designed to capture the trade-off between the sizes of the rotors and the total number of installed turbines.

The outcome of the VCM shows significant differences across the regions examined. The per-turbine productivity in Continental Europe is essentially constant across the dimension of the wind farm. To the contrary, in the British Isles and Scandinavia the amount of capacity installed per turbine changes together with the size of the wind farm. Up to 12 turbines, on-shore projects are more productive, then off-shore dominate. In Scandinavia the most significant difference is observed when 30 turbines are installed (off-shore generates 0.6 MW more per turbine), in the British Isles when 55 turbines are installed (off-shore generates 1 MW more per turbine). From a productivity point of view, these can be considered the 'optimal' projects.

Any further research should identify among the projects which have the best economies-of-scale the ones with the lowest indirect cost focusing on the impact that the 'optimal' design has on the grid, the environment, and the local communities.

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