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PRODUCTIVITY AND PENETRATION OF INTERMITTENT RENEWABLE CAPITAL STOCK

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Overview

Many OECD governments have established ambitious targets for the penetration of renewable energy. Wind and solar power are the renewable energy sources which are growing the fastest and which will have to become increasingly important elements in the electricity supply mixif ambitious targets are to be met. However, the generation of electricity from these sources –along with marine power- is variable and unpredictable. This combination of variability and unpredictability, termed intermittency, poses significant challenges for grid operators since electricity supply and demand needs to be in balance on a continuous basis. While investment in a wide portfolio of renewable energy sources and the spatial dispersion of their location can reduce the risk of loss of load by reducing the correlation in their peaks and troughs, this is not likely to be sufficient as penetration rates rise. Investment in increased capacity of intermittent electricity power sources needs to be complemented with other measures in order to reduce the risk of loss of load and maximize the use of installed intermittent renewable power capacity. In particular, measures which increase grid flexibility and transmission capacity are keys to ensure the efficient use of the intermittent renewable capital stock. Grid flexibility can be achieved through the use of dispatchable power plants (principally gas and hydro), but also energy storage facilities (pumped hydro and advanced energy storage), and advanced grid management (including smart grid technologies). Increased transmission capacity through investment in high-voltage transmission lines allows for the more efficient exploitation of widely-dispersed generating sources within the grid. This can be complemented with high-capacity interconnectors which allow for the greater integration of grids (including cross-border electricity trade).

Method

In this study we have assessed the empirical effect of different factors on the productivity of wind power plants. The econometric model focuses on wind energy since it is the most widely deployed, variable and unpredictable among intermittent renewables. However, the analysis is of broader relevance since it also applies to solar photovoltaic and narine energy sources. Two samples are estimated over the period 1990-2009, 21 European countries and a broader sample including 10 other OECD economies. A measure of available wind power was constructed based on monthly observations of average wind speed at wind power plants. In line with the theoretical model presented, a number of other explanatory variables which are subject to policy intervention are included, namely: i) dispatchable power; ii) storage capacity; iii) transmission capacity; iv) electricity trade; and v) capacity of wind power generation.

Results

In the base model all of the explanatory variables are positive and significant in both samples, with the exception of the measure of relative wind power capacity. In subsequent models the different explanatory variables of interest are interacted with dummy variables reflecting the extent of capacity penetration of wind power. This elaboration is consistent with the conceptual discussion and the theoretical model developed. While grid capacity and dispatchable power have a constant impact over different capacity penetration rates, it is found that energy storage has an increasing impact on wind plant productivity with increasing penetration. In the case of electricity trade the effect only becomes statistically significant once a penetration rate equal to the upper threshold is exceeded. However this is equal to 3% capacity penetration (this roughly corresponds to domestic wind power generation being equal to 1.5% of total power generated in the country), indicating that trade will have positive consequences for most countries as target objectives are approached. The results of the model have important implications for the efficacy of different measures adopted to facilitate the integration of intermittent renewable energy plants in the grid.

Conclusions

Our study shows that society might incur much larger costs of meeting its renewable targets if the grid is not adequately developed in parallel with increased intermittent renewable generation capacity. Even if ecological conditions allowed for generation in principle, large amounts of the capital stock will be unused at any given point in time. The deployment of power plants using intermittent renewable energy sources to generate electricity should therefore be promoted along with transmission capacity and grid flexibility (including cross-border electricity trade) in order to securing their productivity. It is hence important to assess the necessary investments in grid flexibility and transmission capacity in accordance with renewable policy objectives, and introduce incentives for all agents (plants owners, grid operators) to encourage such investments.

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