

Wind Energy, the Price of Carbon Allowances, and CO₂ Emissions: Evidence from Ireland

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Using data from Ireland, this paper examines the effects of wind energy and the EU ETS allowance price on carbon emissions from electricity generation. The analysis employs a time-series econometric model of CO₂ emissions for each half-hour over the period 1 January 2015 through 31 December 2016. Explanatory variables include a weighted measure of the carbon allowance price, the MWh equivalent fuel price of coal relative to the MWh equivalent price of natural gas, the share of load accounted for by wind energy generation, along with measures of expected vs realized electricity load, the error in the wind energy forecasts, and the ex post vs ex ante system marginal electricity price. The structural model has a nonlinear specification based on the Box Cox and multivariable fractional polynomial (MFP) methodologies. The model is estimated using ARCH/ARMA methods with an allowance for “fat tails.”

The results are consistent with the hypothesis that an increase the price of a carbon allowance has the effect of reducing carbon emissions. The results also indicate that the carbon reducing effect of a higher allowance price is more muted when the wind energy penetration level is high. All other factors being held constant, the “marginal” effect of an increase in wind energy penetration on CO₂ is not constant. The results indicate that the CO₂ benefits of wind energy penetration given current operational methods are maximized at about 70 % of electricity load.

An out-of-sample analysis was performed using half-hour data over the period 1 January through 31 December 2017. Over this evaluation period, the predictive R² equals 0.985 when all the parameter estimates, including the AR, MA, ARCH, and conditional variance terms are considered (Figure 1). We believe that this out-of-sample performance is an encouraging indicator of the model’s adequacy.

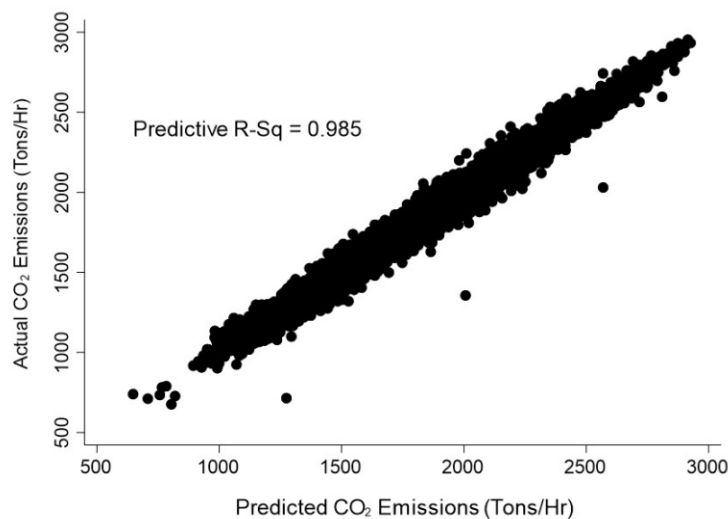


Figure 1. The model’s out-of-sample predictive accuracy, 1 Jan 2017 through 31 December 2017