***the long-term effect of renewable electricity in the UK employment***

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## Overview

Renewables technologies are considered to be a key component in the mitigation of climate change while they are expected to create a number of new employment opportunities in various sectors through direct and indirect employment effects. Although there is a large number of studies investigating the potential employment effect from the deployment of renewables technologies, these studies tend to focus on specific renewable technologies, locations and plants and to ignore the employment effect of conventional thermal and nuclear technologies. Assessment of the employment impact of renewable electricity technologies is generally implemented through either complex and data-intensive methods (such as Computable General Equilibrium models) or simplistic approaches, normally focused on specific technologies, such as employment factors.

The aim of this study is to produce a rigorous but simple approach to the empirical quantification of the employment effects of technologies used in the production of electricity which can be implemented by using relatively aggregated data. By avoiding the data burder of typical of Input-Output, CGE and macroeconometrics sectorial model, the proposed methodology can quantify the employment impact of a number of renewable technologies in a fully transparent way while it can also be applied on the back of the output of energy system models which produce deployment scenarios of electricity generation technologies to achieve a certain level of decarbonisation. Ability to use annual data rather more granular observations increases the applicability of our method which uses data which are readily available for at least OECD countries. As far as we are aware, our study is the first cointegration analysis that examines the long-term relationship between employment and renewable electricity while taking also into account the employment effect of energy supplied by conventional thermal, combined cycle gas turbine (CCGT) and nuclear technologies using long-term historical data. By estimating the long-run equilibrium between employment, gross value added (GVA) and electricity supply for the electricity generation sector we investigate a number of key questions related to that. We provide evidence that the increase in employment related to a permanent rise in the generation of renewable electricity is several times higher than the employment effect of an equivalent increase in electricity generated by nuclear or natural gas.

## Methods

In order to estimate the long-run effect of renewable technologies on employment we implement a two-step methodological approach. First of all, we search for evidence of long-run relationships, by implementing a cointegration analysis using a VAR approach (Johansen, 1988; 1991), and estimate a Vector Error Correction (VECM) model of order p, where all variables are treated as endogenous. Once we have identified the long-term relationship between employment, output and electricity supply, in the second step we use our model to compute the long-term response of employment to a positive shock in the electricity supply of each type of power generation technology using impulse response function (IRF) analysis. More specifically, the IRF is used to understand the effect of a positive permanent shock on electricity supply at time *t* on employment from time *t* to *t+n*. We examine the response of employment to a 1 GWh increase, independently taking place in each electricity production technology. As we estimate a reduced form model, we use the generalised impulse response function (Koop et al, 1996) which is invariant to the ordering of the variables in the VAR and “fully takes into account the historical patterns of the correlation observed amongst the different shocks” (Pesaran and Shin, 1998; Pesaran and Smith, 1998). Finally, evaluate the policy implications of our results, we apply the estimated employment effect on a set of scenarios for electricity generation in 2030 in the UK produced by the UKTM model (Watson et al, 2018).

## Results

Our results indicate there is a positive scale effect between output and employment in the UK electricity generation sector revealing an approximate one-to-one relationship between percentages increases in GVA and jobs. We further find that evidence of substitution between conventional thermal electricity supply on the one side and gas, nuclear and renewables electricity supply on the other side. The IRF analysis indicates that a permanent 1 GWh increase in the annual electricity supply generated by renewable technologies creates 4.7 new jobs in the short-term period while the long-term employment effect is 3.5 jobs. Thus, our results indicate that 3/4 of the jobs created by the deployment of renewable technologies are sustainable in the long run. With regard to nuclear electricity supply, a 1 GWh increase creates 0.81 jobs in the short-term period – 6 times lower than those created by an equally sized increase in renewable electricity – while in the long-term period employment stabilises at 0.54 jobs, i.e. 2/3 of the created jobs are sustainable in the long run. As a result, the employment effect of nuclear electricity is not only much smaller in absolute terms than that of renewable electricity but also less sustainable. When it comes to CCGT technologies, the short-term employment effect is 0.57 jobs – 8 times lower to the that created by an equal sized increase in renewable electricity – while the long-term effect is 0.36 jobs.

From a policy perspective, and as a way of testing our methodology, we investigate the potential future employment effect from a set of scenarios for electricity generation in 2030, produced by the UKTM model (Watson et al, 2018). We use as a counterfactual the “Energy island” scenario which is the only one to assume that conventional thermal technologies will be used until 2030. According to our methodology, renewable technologies are expected to create from a minimum of about 16,000 jobs (29% of the electricity is generated by renewable technologies) to a maximum of about 186,000 jobs (when 64% of the electricity is generated by renewable technologies and overwhelmingly by wind turbines). In contrast to the counterfactual in which there is negative net employment effect, all scenarios generate a positive net employment effect which takes the minimum value of about 12,000 and the maximum of about 152,500 jobs. Therefore, our results indicate that further support of renewable technologies in the UK results in the creation of a significant number of long term jobs in the power generation sector.

## Conclusions

This article proposes a transparent and easily replicable methodology to estimate the employment effect of electricity generation technologies by using aggregated data on the economic activity and employment in the power generation sector, and amount of electricity produced by different technologies. For the first time in the literature, we provide empirical evidence on the long-term effect of renewable electricity supply on net employment while taking also into account the employment effect of conventional thermal, natural gas and nuclear electricity supply through standard cointegration analysis. In terms of the employment implications of electricity generation technologies, we found that the long-term response of employment to an permanent 1 GWh increase in the supply of renewable electricity markedly differ from the employment generated by nuclear and gas generation. More specifically, a 1 GWh permanent increase in renewable electricity supply creates 3.5 jobs in the long-term, i.e. about six times the number of jobs created by an equally sized increase in nuclear generation. We also show that the jobs created by the deployment of renewable technologies are the most sustainable in the long-term period.

Our results indicate that most of the scenarios in Watson et al (2018) imply increasing employment in the electricity generation sectors, in some cases quite substantial. We find that several of the energy security scenarios imply an increase in the employment in the electricity production sector, with these changes implied by the six scenarios ranging between a decrease of 12,000 jobs to and an increase of 150,000 jobs. Scenarios where electricity generation is based overwhelmingly on renewable electricity results in up to 1.5 times more jobs than in a scenario where UK power generation sector continues to rely mainly on nuclear and conventional thermal technologies. Therefore, it is crucial that policy-makers incentivise and support the further deployment of renewable electricity technologies as we find robust evidence of their employment impact in scenarios aimed at progressing the decarbonisation of the UK economy.

## References

Johansen S (1988) “Statistical analysis of cointegration vectors.” *Journal of Economic Dynamics and Control* 2-3: 231-254.

Johansen S (1991) “Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models.” *Econometrica* 59(6): 1551-1580

Koop G, Pesaran H and Potter S (1996) “Impulse response analysis in nonlinear multivariate models.” *Journal of Econometrics* 74(1): 119-147.

Pesaran H and Shin Y (1998) “Generalized impulse response analysis in linear multivariate models.” *Economic Letters* 58: 17-29.

Pesaran H and Smith R (1998) “Structural analysis of cointegrating VARs.” *Journal of Economic Surveys* 12(5): 471-505.

Watson J, Ketsopoulou I, Dodds P, Chaudry M, Tindemans S, Woolf M and Strab G (2018) *The security of UK energy futures.* London, UK Energy Research Centre.