THE IMPACT OF ENERGY TRANSITION ON LOCAL GRID COSTS AND CONSEQUENCES FOR YARDSTICK REGULATION: EMPIRICAL ANALYSIS FOR THE NETHERLANDS

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Overview

In several regulated industries, the allowed revenue of firms is determined in a yardstick regulation framework. In this type of regulation the allowed revenue of a regulated firm is based on the average costs of a reference group of identical firms (Shleifer, 1985). However, firms may not always be identical, and exogenous factors may cause regulated firms to have inherently different cost levels (Joskow, 2014). In this case, a multivariate average-cost function can be used to calculate a firm-specific yardstick, which takes into account exogenous heterogeneity among regulated firms (Filippini and Wild, 2001).

In our paper, we focus on electricity distribution network operators (DNOs) subject to yardstick regulation. Earlier research has indicated that in electricity distribution there may be several exogenous factors causing heterogeneity among firms. For example, Filippini and Wild (2001) conclude that exogenous characteristics of the service area, such as customer density and area shares of different land types, significantly affect network costs. Therefore, the benchmarking of allowed revenue for DNOs requires a careful consideration of exogenous cost drivers (Neuberg, 1977; Jamasb and Pollitt, 2003).

In particular, we study the effect of exogenous factors related to the energy transition on the average costs of DNOs. This is a key topic because the energy transition is profoundly changing the nature of both generation and load connected to the distribution network (MIT, 2016). Distribution networks are facing large-scale integration of distributed generation (DG), such as solar PV and on-shore wind power plants, and integration of other distributed energy resources (DERs), such as batteries, electric vehicles and heat pumps. As a consequence, DNOs may have to invest substantially in order to expand network capacity and guarantee network safety and reliability. Already, there is some evidence that the integration of electric vehicles and distributed generation is leading to increased network costs (Hinz et al. 2018; Wangness and Halse, 2021)

We estimate an average-cost function to study the effect of exogenous factors related to the energy transition on average network costs for a panel of Dutch DNOs subject to yardstick regulation. In our regression analysis, we include several variables related to the energy transition, such as the installed capacity of solar PV and on-shore wind and the number of regular charging points.

Our empirical findings are as follows. In the preferred specification we find that the installed capacity of solar PV and the installed capacity of on-shore wind both have a significant impact on network costs. The impact of EV charging points is insignificant, which is somewhat unexpected, given the findings by previous research (Wangness and Halse, 2021).

Building on our empirical results, we assess the Dutch case of yardstick regulation. First, we answer whether energy transition causes DNOs to be heterogenous and and have inherently different cost levels. Second, we show how the regulator could apply a multivariate average-cost function to correct for heterogeneity in a yardstick regulation framework (Filippini and Wild, 2001). Third,we quantify distributional effects among DNOs that would arise from this exercise (compared to a yardstick that does not take into account heterogeneity among firms).

In short, our contribution to the literature is twofold: a) we identify which factors related to the energy transition impact total network costs, and b) we study how these factors can be integrated in a yardstick regulation framework, such that the regulator can take into account heterogeneity among DNOs' when determining the allowed revenue in this type of regulation.

Methods

We estimate a multivariate average-cost function for an unbalanced panel of Dutch electricity distribution network operators (DNOs) for the period 2012 to 2020. Our sample consists of the entire population of Dutch DNOs, which consisted of 8 DNOs in 2012. After a merger occurred in 2015, there were 7 DNOs remaining.

In our average-cost function, we include an output measure, input prices, and a vector that describes exogenous heterogeneity between firms. This approach acknowledges that a given combination of output(s) and input prices may be associated with different levels of network costs, depending on the vector of exogenous heterogeneity factors.

We choose the total number of connections as our output, which is a common measure in the literature (Neuberg, 1977; Burns and Weyman-Jones, 1990). Our cost measure is average costs, measured as the total costs divided by total output. For our vector that describes exogenous heterogeneity, we focus mostly on energy transition variables. We include the installed capacity of solar PV in MW, installed capacity of on-shore wind in MW, and the number of regular EV charging points. All these variables are expressed as a number per 1000 connections. Based on the literature, we also include two variables that describe the service area (Filippini and Wild, 2001). We include the customer density measured as the number of customers per square kilometre and the total size of the service area in square kilometres.

Results

We first estimate our average-cost function using a pooled ordinary least squares (OLS) model. To exploit the panel nature of our data, we also estimate a fixed-effects (FE) model. The advantage of this FE model is that it controls for any unobserved time-invariant effects on the DNO level. However, Wooldridge's test for unobserved individual effects favours the pooled OLS model. So, the pooled OLS is our preferred model. All models are estimated with Newey-West heteroskedastic robust standard errors.

In both models, the selected energy transition variables have the expected positive sign. In the pooled OLS model, the coefficients for the installed capacity of solar PV per 1000 connections, and the installed capacity of wind power per 1000 connections are significant at the 1 percent level. Turning to the FE model, the installed capacity of wind power remains significant at the 5 percent level. The installed capacity of solar PV is only weakly significant at the 10 percent level.

Conclusions

In our paper, we estimated an average-cost function for an unbalanced panel of 8 DNOs. The main novelty of our research is the careful consideration of several heterogeneity factors related to the energy transition. We showed that some factors related to the energy transition, such as installed capacity of solar PV and installed capacity of on-shore wind, significantly impact total network costs. Hence, we may conclude that the integration of DG, which in the Netherlands mostly consists of solar PV and on-shore wind, causes DNOs to have higher network costs.

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