

VREs and Firm-Level Generation Decisions: Evidence from the Turkish Wholesale Electricity Market

Selahattin Murat Sirin, Western University, ssirin@uwo.ca

Dilek UZ, University of Nevada - Reno, dilekuz@unr.edu

Irem SEVINDIK, University of Nevada - Reno, irems@nevada.unr.edu

Overview

This paper presents firm level estimates of how an increase in the VRE generation affects individual firms' day ahead available-capacity and generation plans in a developing country context, Turkey. In addition to having a fast-growing energy demand and high renewable energy potential, Turkey represents an understudied market case where the market leader, unlike the rest of the generators, is a public enterprise which potentially prioritizes political motives over economic efficiency. Our results support the existing concerns that the public enterprise, especially during the times of financial turmoil, acts with the motivation to stabilize market prices. Additionally, we find that there is a significant heterogeneity in firms' response to VREs and individual responses significantly differ from the aggregate market response.

Methods

We start out with clustering firms' generation profiles in comparison to the projected VRE generation, projected residual demand, and market-clearing price using agglomerative hierarchical time-series clustering (HTSC). We use both the Euclidian distance metric, which is the de facto approach in forming similarity/dissimilarity matrix, and the correlation-based distance metric to better represent the relationships between the variables [1].

A firm participating in the day-ahead market submits its bids (quantity-price pairs) and available capacity for each hour of a given day all at once. Hence, bids for a given hour are likely to be correlated with those for other hours within the same day due to some unobserved common factors. In addition, the magnitude of the correlation may vary across the hours. Therefore, independent error term assumption may not be realistic for this case. The common correlated effects mean group estimator (CCEMG) is one of the approaches to incorporate cross-section error correlations in the regression model by approximating the unobserved factors with cross-sectional averages of the dependent and independent variables [2,3]. Furthermore, this approach allows heterogenous slope coefficients, and it obtains panel coefficients by taking the averages across the cross-sectional units.

Results

Our econometric analysis features 59 firms (corresponding to 60% of the total installed capacity) that either fully or partially operate dispatchable technologies. We observe three different types of responses in available capacity to changes in projected VRE generation: (i) 12 firms have positive and significant coefficients; (ii) 20 firms have negative and significant coefficients; and (iii) 27 firms have statistically insignificant coefficients. There is a considerable amount of heterogeneity across firms' capacity response to an increase in the projected VRE generation. The aggregate coefficient for the VRE, on the other hand, is statistically indistinguishable from zero. The EUAS has statistically significant and positive coefficients for both VRE generation (0.003, p-value < 0.01) and residual demand (0.008, p-value < 0.05). This is consistent with the theoretical expectations: state-owned enterprise may have motives different than profit maximization and hence unlike the private firms, it is not expected to withhold capacity in the face of increasing VRE output.

In terms of generation profiles, we see the aggregate non-VRE generation responds to VRE generation as predicted by theory. Consistently, there are three types of responses to VRE generation: (i) 19 firms have positive and statistically significant coefficients; (ii) 19 firms have statistically insignificant result; (iii) 21 firms have negative and statistically significant results. Among thermal-only power plants, 13 firms have negative coefficients while 6 firms have positive, and 13 firms have statistically insignificant coefficients. On the other hand, the EUAS has statistically insignificant coefficient, which supports our idea that due to EUAS potentially having a different priority than profit maximization, it does not necessarily hold available capacity or reduce generation as a response to increasing VRE generation, or it does not exercise market power.

There are multiple possible explanations of heterogeneity in firm response to VREs. First, while the private firms do have the general goal to maximize profit, the constraints within which they operate can differ considerably, leading to differences in the way they respond to changing conditions as discussed in the literature. Such a concern would introduce additional constraints into their maximization problem limiting their ability to focus on short term gains via flexible patterns in their day ahead generation profiles. Hence, some firms may prefer being dispatched at multiple hours using block bids; therefore, their position with respect to VRE generation differs from what is conjectured in theory. Additionally, arbitrage opportunities between the day-ahead market and balancing market may lead to different generation strategies even if firms have the same technologies. Hence, this interaction should also be analyzed to understand firm strategies better.

Second, firm analytical capabilities and human resources also differ, and this may be another cause of different responses. Some large firms have developed in-house market analysis teams with significant human resources – employees with graduate-level education in mathematics, statistics, and engineering. On the other hand, some small firms have limited analytical capabilities forcing them to rely on simpler analytical methods or external consultants, or simply following the major players. While these characteristics are hard to observe publicly, further inquiries in firm capabilities are likely to improve our understanding of firm behavior.

Conclusions

These results have some important implications for energy market reforms in developing countries. Turkey initiated electricity market restructuring almost two decades ago, yet the empirical evidence suggests that the public enterprise is still yet to adapt to market-oriented operational objectives. Countries that are at the initial stages of their reform process may encounter similar problems. If the public enterprise is used in electricity market operations with political or social motives, the market will not be effective in creating investment signals as it is supposed to and hinder new energy investments required for the targeted transition over the long term. Therefore, establishing an electricity market is not sufficient unless it is also supported with structural reforms to eliminate any political interventions to electricity markets.

The overarching insight from the existing literature as well as our stylized conceptual framework suggests that the non-VRE output should decline as the VRE output increases. However, we find there is a significant degree of heterogeneity in response at the firm level where the individual responses differ from the aggregate response to a great extent. This highlights the importance of conducting the analysis at the firm level since the aggregate result could fail to provide a full understanding on its own. Possible explanations for firm heterogeneity besides capacity mix are different financial or human resource constraints under which the firms might be operating.

References

- [1] Iglesias F, Kastner W. Analysis of Similarity Measures in Times Series Clustering for the Discovery of Building Energy Patterns. *Energies* 2013;6:579–97. <https://doi.org/10.3390/en6020579>.
- [2] Mohammadi H, Parvaresh S. Energy consumption and output: Evidence from a panel of 14 oil-exporting countries. *Energy Econ* 2014;41:41–6. <https://doi.org/https://doi.org/10.1016/j.eneco.2013.11.002>.
- [3] Ditzen J. Estimating Dynamic Common-Correlated Effects in Stata. *Stata J Promot Commun Stat Stata* 2018;18:585–617. <https://doi.org/10.1177/1536867X1801800306>.
- [4] Qiao H, Chen S, Dong X, Dong K. Has China's coal consumption actually reached its peak? National and regional analysis considering cross-sectional dependence and heterogeneity. *Energy Econ* 2019;84:104509. <https://doi.org/https://doi.org/10.1016/j.eneco.2019.104509>.