Interconnection Capacity Allocation Method: First-Come, First-Served Rule to Implicit Auction

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Overview

Interconnected transmission network not only supports larger markets for competition but also balance demand and supply in a large penetration of variable renewable energy. However, interconnection capacity is a scarce resource, because it is historically built for reliability reasons rather than economic trade. Hence, market design for efficiently allocating the scarce transmission capacity is important. Generally, there are four congestion management methods: first-come-first-served, pro-rata, explicit auction, and implicit auction also called market splitting or market coupling (European Transmission System Operators 1999, 2004). The first two methods are non-market-based schemes, whereas the latter two are market-based. Plenty of literature studies the inefficiency of explicit auction compared to implicit auction in the European context of the market coupling (e.g., Bunn and Zachmann 2010; Brunekreeft, Neuhoff, and Newberry 2005; Creti, Fumagalli, and Fumagalli 2010; Ehrenmann and Neuhoff 2009; Füss, Mahringer, and Prokopczuk 2020; Gugler, Haxhimusa, and Liebensteiner 2018; Keppler, Phan, and Le Pen 2016; Newbery, Strbac, and Viehoff 2016). Another strand of literature focuses on the impact of renewable generation on the domestic and neighboring markets in conjunction with interconnector capacity (Annan-Phan and Roques 2018; Abrell and Kosch 2022; LaRiviere and Lyu 2022; Gugler and Haxhimusa 2019; Woo et al. 2011; Keppler, Phan, and Le Pen 2016). However, there is little empirical evidence regarding the impact of the transition from a non-market-based rule to a full implicit auction. Little is known about the quantitative impact when first-come-first-served is replaced by implicit auction.

First-come-first-served (FCFS), one of the non-market-based rules, allows only incumbents to reserve the capacity for free well in advance before the wholesale day-ahead market clears. Similar to an explicit auction, traders must first acquire interconnector capacity ex-ante before the day-ahead market allocates corresponding energy across zones. Reservation was allowed not only for keeping up to 10 years but also for its renewal. It was allowed effectively as legacy non-tradable physical transmission rights. Consequently, the day-ahead market could only allocate the remaining interconnection capacity. Moreover, those who could reserve can also cancel the reservation even after the day-ahead market clearing, leaving unused capacity. This implies that they can strategically withhold the transmission capacity from the market. Furthermore, when the remaining capacity overflows the scheduled flow, the market has been split and the prices diverge between export and import zones under the zonal pricing. This might give incumbents the incentive to withhold the interconnection capacity because the zone price in importing zones becomes higher and the value of their local generation resource increases (Bushnell 1999). Hence, this study investigates how much the implicit auction improves economic efficiency relative to FCFS. Under full implicit auction, incumbents could no longer reserve the capacity, and all net transferable capacity (NTC) is allocated in the day-ahead market.

This study focuses on Japan where the FCFS rule has long been used, even after liberalizing generation and retail markets by 2016. Unlike European countries, Japan never used explicit auctions. Japan has a single power exchange (Japan Electric Power eXchange: JEPX) operating national wholesale markets together with nine TSOs. The day-ahead market adopts zonal pricing, and a full implicit auction was introduced on 1st October 2018. Thus, Japan provides a unique opportunity to study the effect of the transition from the non-market-based method to the implicit auction. Moreover, we can avoid potential omitted variable bias. When we model two countries in Europe (e.g., Germany and France), these counties are connected by neighboring counties whose covariate data is often not available. By contrast, Japan is not connected to other countries and all zonal data is available. An additional advantage of studying Japanese interconnectors is that its network is effectively radial and our analysis does not suffer from loop flow issues.

Methods

We leverage rich hourly data to estimate the effect of the implicit auction on market efficiency gain. We first estimate the volume effect: full implicit auction forces suppliers and retailers to join the day-ahead market to gain interconnection capacity and increase the amount of bid/offer quantity. We exploit the shape of the supply curve and the fact that a demand curve crosses at a steeper part of the supply curve during the peak period to identify the effect of the implicit auction on system price. Second, we estimate the trade effect of implicit auction. Increased interconnection capacity available in the day-ahead market enables more trade and reduces the price gap between

import and export regions. We focus on two interconnectors where congestions were most severe during the study period: Hokkaido-Honshu line connecting Hokkaido and East zones and Frequency Converter connecting between East and West zones. An instrumental approach is used to address the simultaneity of the price gap and trade quantity. We then estimate the welfare gain of implicit auction.

Results

We find that implicit auction has an economically significant impact on welfare. The volume effect is over $ 500 million/year. We also find the trade effect in both interconnectors. Annual production cost saving by the increased trades is about $ 24.1 million across Hokkaido-Honshu line and $ 93.3 million across Frequency Converter after the five-month of implementation. The total annual efficiency gain is about $ 280 million. The overall annual benefit of implicit auction amounts to $ 780 million.

Conclusions

This study highlights the full merit of implicit auction relative to a non-market-based method. Implicit auction improves an efficient resource allocation in the day-ahead market even without costly upgrading of the interconnection. It is known that, unlike an explicit auction, the implicit auction can avoid economically inefficient use of interconnection capacity, i.e., export from high price zone to low price zone. However, this article shows that implicit auction can also reduce underutilization caused by the cancellation of reserved capacity under FCFS.

References

Abrell, Jan, and Mirjam Kosch. 2022. “Cross-Country Spillovers of Renewable Energy Promotion—The Case of Germany.” *Resource and Energy Economics* 68 (May): 101293. https://doi.org/10.1016/J.RESENEECO.2022.101293.

Annan-Phan, Sebastien, and Fabien A Roques. 2018. “Market Integration and Wind Generation: An Empirical Analysis of the Impact of Wind Generation on Cross-Border Power Prices.” *The Energy Journal* 39 (3). https://doi.org/10.5547/01956574.39.3.spha.

Brunekreeft, Gert, Karsten Neuhoff, and David Newberry. 2005. “Electricity Transmission: An Overview of the Current Debate.” *Utilities Policy* 13 (2 SPEC. ISS.): 73–93. https://doi.org/10.1016/j.jup.2004.12.002.

Bunn, Derek, and Georg Zachmann. 2010. “Inefficient Arbitrage in Inter-Regional Electricity Transmission.” *Journal of Regulatory Economics* 37 (3): 243–65. https://doi.org/10.1007/s11149-009-9104-5.

Bushnell, James. 1999. “Transmission Rights and Market Power.” *The Electricity Journal* 12 (8): 77–85. https://doi.org/10.1016/s1040-6190(99)00074-3.

Creti, Anna, Eileen Fumagalli, and Elena Fumagalli. 2010. “Integration of Electricity Markets in Europe: Relevant Issues for Italy.” *Energy Policy* 38 (11): 6966–76. https://doi.org/10.1016/j.enpol.2010.07.013.

Ehrenmann, Andreas, and Karsten Neuhoff. 2009. “A Comparison of Electricity Market Designs in Networks.” *Operations Research* 57 (2): 274–86. https://doi.org/10.1287/opre.1080.0624.

European Transmission System Operators. 1999. “Evaluation of Congestion Management Methods for Cross-Border Transmission.” *Florence Regulators Meeting*. https://eepublicdownloads.entsoe.eu/clean-documents/pre2015/ntc/archive/Evaluation_of_congestion_management_methods_for_cross-border_transmission_(Florence).pdf.

———. 2004. “An Overview of Current Cross-Border Congestion Management Methods in Europe Table of Contents.”

Füss, Roland, Steffen Mahringer, and Marcel Prokopczuk. 2020. “Electricity Market Coupling in Europe: Status Quo and Future Challenges.” In *Handbook of Energy Finance: Theories, Practices and Simulations*, 93–120. World Scientific Publishing Co. https://doi.org/10.1142/9789813278387_0005.

Gugler, Klaus, and Adhurim Haxhimusa. 2019. “Market Integration and Technology Mix: Evidence from the German and French Electricity Markets.” *Energy Policy* 126: 30–46. https://doi.org/10.1016/j.enpol.2018.10.014.

Gugler, Klaus, Adhurim Haxhimusa, and Mario Liebensteiner. 2018. “Integration of European Electricity Markets: Evidence from Spot Prices.” *Energy Journal* 39 (Special Issue 2): 41–66. https://doi.org/10.5547/01956574.39.SI2.kgug.

Keppler, Jan Horst, Sébastien Phan, and Yannick Le Pen. 2016. “The Impacts of Variable Renewable Production and Market Coupling on the Convergence of French and German Electricity Prices.” *The Energy Journal* 37 (3). https://doi.org/10.5547/01956574.37.3.jkep.

LaRiviere, Jacob, and Xueying Lyu. 2022. “Transmission Constraints, Intermittent Renewables and Welfare.” *Journal of Environmental Economics and Management* 112: 102618. https://doi.org/10.1016/j.jeem.2022.102618.

Newbery, David, Goran Strbac, and Ivan Viehoff. 2016. “The Benefits of Integrating European Electricity Markets.” *Energy Policy* 94 (July): 253–63. https://doi.org/10.1016/j.enpol.2016.03.047.

Woo, C K, J Zarnikau, J Moore, and I Horowitz. 2011. “Wind Generation and Zonal-Market Price Divergence: Evidence from Texas.” *Energy Policy* 39 (7): 3928–38. https://doi.org/10.1016/j.enpol.2010.11.046.