Congestion Risk, Transmission Rights, and Investment Equilibria in Electricity Markets

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In liberalized electricity markets, producers' revenues depend on uncertain and volatile electricity prices. Financial instruments that provide predictable revenue streams are therefore crucial to acquire project finance. As a result, the ability or inability to trade risk impacts the cost of capital and influences incentives for investments in different generation technologies. Utilities have historically been counterparties for financial contracts, but financial institutions and corporations are increasingly taking this role. These new actors prefer to settle contracts at liquid hub locations rather than project locations. In nodal electricity markets, where each node in the system has a unique electricity price based on its locational marginal cost, this introduces locational basis risk for producers because they sell electricity at their node but must settle energy price hedges at a hub node with different prices. In U.S. markets, an instrument called a financial transmission right (FTR) pays the price difference between two locations and should be able to protect against locational risks. In practice, however, FTR durations are far shorter than the requirements of project finance and it may not be possible to acquire them before a project must secure financing. The industry therefore reports that FTRs are not used in project finance and that the inability to protect against locational risks remains a concern. This suggests that markets for risks are incomplete, which incentivizes suboptimal investments from a social surplus perspective. More specifically, projects at remote locations are put at a disadvantage because they cannot protect against locational risks. This is a particular concern from a decarbonization perspective, since investments in solar and wind are often located at remote locations because of land availability and resource quality.

In order to investigate incomplete markets for both energy price and locational risks, we run experiments on a two-node power system with a remote node and a central hub node. Producers invest in generation capacity and trade financial instruments in a first stage, while considering several scenarios of electricity market operations that unfold in the second stage. Financial contracts can protect against the scenarios with the worst outcomes. This helps secure revenues and consequently impacts the cost of capital for the investment technologies. The model has three generation technologies (variable resource, baseload, and peaker), three energy price hedges (unit contingent contract (a simple form of a power purchase agreement (PPA)), futures, and call options), and FTRs to protect against locational risks. Each energy price hedge matches the risk faced by a particular producer and all contracts match the project lifetime. All energy price hedges settle at the liquid hub node and thus the variable resource and baseload at the remote node face locational risks. We compare the results against a model with complete risk trading, which is the benchmark for surplus-maximizing investments.

The results show that the possibility to protect against locational risks have a positive impact on project financing. It decreases cost of capital and creates incentives for investments that are closer to the surplus-maximizing benchmark. Only producers on the remote node are interested in FTRs because they face locational risks by selling energy at remote node prices and acquiring energy price

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hedges that track hub node prices. Whenever FTRs are the only available instrument, there are no interest for it. This is because it will just shift price risk exposure from the remote node to the hub node, and hence not reduce it. Remote producers only acquire FTRs when they can combine it with energy price hedges and thus achieve more revenue certainty than from energy price hedges alone.

In order to reach environmental targets set for 2050, the power system requires unparalleled generation investments. A large share of this is bound to come from geographically remote locations. Our results suggests that without a means to sufficiently protect against locational risks, markets for risk are in danger of becoming incomplete and may incentivize suboptimal investments. From a policy perspective, reforms to existing FTR allocation and auction designs could improve protection against locational risks. Potential reforms include changing the timing of auctions so projects can acquire FTRs before securing financing, offering an option for new generators to purchase long-term FTRs as part of the interconnection process, or allocating hedges by default to parties with the highest locational risks.