Welfare impacts of optimal virtual bidding in a multi-settlement electricity market with transmission line congestion

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Introduction

- Virtual bids are purely financial instruments to speculate on the differences between prices in the forward and spot markets in a two-settlement electricity market.
- While the price convergence across these markets can be induced by virtual bidding, if it does so by inflating the prices, then electricity consumers may not be better off.
- Although some work has been done on the impacts of virtual transactions on welfare for the electricity market participants, that work provides an incomplete assessment, ignoring the electricity network as well as the physical laws governing electricity flows.

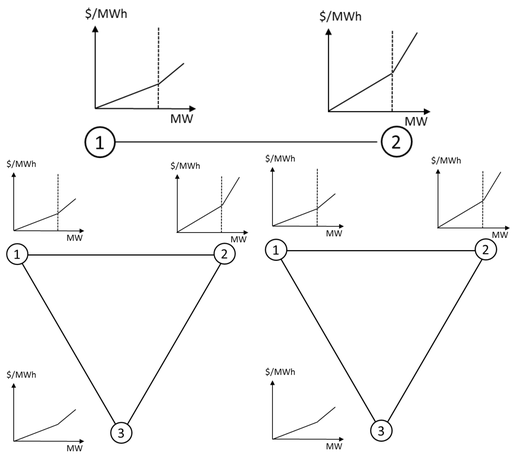
Objective

- The objective of this research is to understand the effect of virtual transactions on electricity market efficiency using a model that explicitly includes the network as well as relationships that reflect the physical properties of electricity flows through a network such as loop flow.
- The core research question is; what impact does network congestion have on the welfare shifts caused by the participation of financial virtual traders?

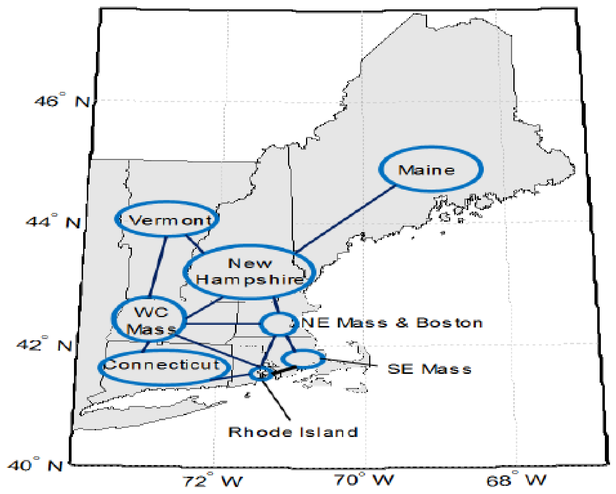
Method

- This study employs models with multiple buses to analyze the welfare changes of electricity market participants in a network constrained multi-settlement electricity market.
- Use stylized two-settlement market with strategic bidders in a network to determine optimal bidding behavior of a virtual trader and the impact of the bids on social welfare.
- Integrate power network in the model enables a comparison of welfare changes between the simpler network-free models and a network based model with the possibilities of line congestion and proper treatment of loop flow.
- Employ different types of network from single, two-bus, three-bus to aggregated ISO-NE test case to check consistency of the impact of virtual transactions on the wholesale electricity market.
- Adopt Monte Carlo method to test sensitivity of electricity market environment and network setting to derive generalized results.

Two- and Three Bus



ISO-NE Test Case



Results

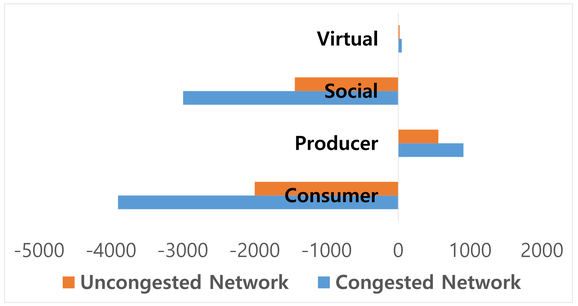
- Having virtual transactions in the uncongested network will decrease consumer welfare and increase producer welfare in the network.
- Having virtual transactions in the congested network will amplify welfare change of market participants in the network: relatively further decrease consumer welfare while increase producer and virtual trader welfare.
- Having virtual transactions in the congested network will amplify welfare change of market participants adjacent to the congested line: decrease consumer welfare more in withdrawal bus relative to the injection bus while increase producer welfare more in withdrawal bus relative to the injection bus.
- The possibility of having line congestion due to demand uncertainty can change the optimal bidding strategy of the financial trader and the welfare impacts on market participants.

Conclusion

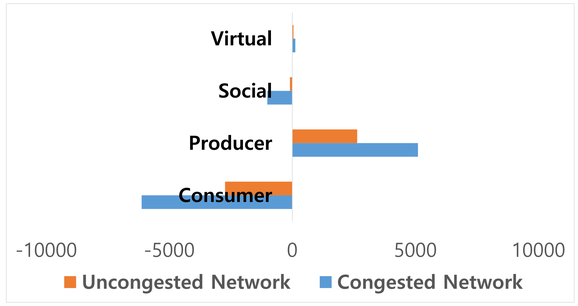
- Many studies use the degree of price convergence to represent improved electricity market efficiency by virtual transactions. However, the system design and bidding strategy may not support the touted benefits of virtual bidding, price convergence in nodal levels.
- The results suggest that the price divergence in nodal levels exists and are commonly persistent and there are welfare transfers among producers, consumers, and virtual traders relative to the market equilibrium

Welfare impacts of virtual and congested network

Two- and Three Bus Simulation

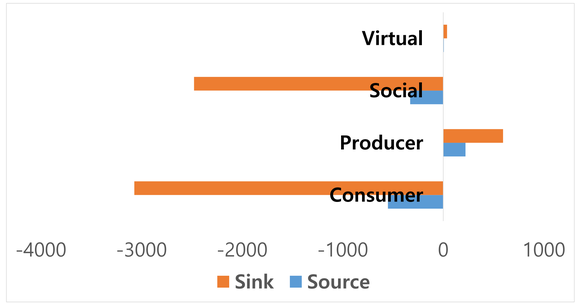


ISO-NE Test Case Simulation

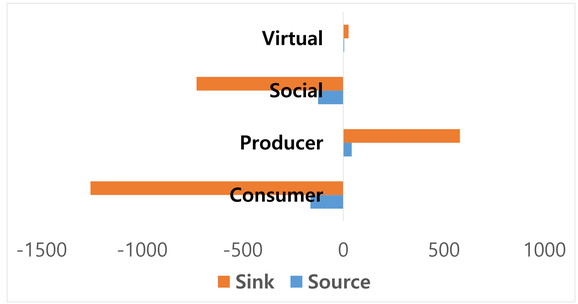


Heterogeneous welfare impacts of virtual in congested network

Two- and Three Bus Simulation



ISO-NE Test Case Simulation



Note: Congestion is generated by adjusting the capacity of line as 80% of power flow (MW) on that line in DA without virtual. Network impact is a sum of the buses in the network. Source and sink are buses adjacent to (next to) the each congested line. Source is a bus located at the start point of the predominant power flow adjacent to the congested line. Sink is a bus located at the start point of the predominant power flow adjacent to the congested line. Magnitudes are averaged from different model types and cases.