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Efficiency of financial transmission rights markets in centrally coordinated periodic auctions

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ABSTRACT

Electricity market design in the United States is increasingly dominated by locational marginal pricing (LMP) of energy and transmission. LMP markets are typically coupled with periodic auctions of financial transmission rights (FTRs) to hedge transmission price risks. While LMP designs offer considerable advantages, forward price discovery in these markets requires participants to form efficient expectations on spot congestion price differences. In this paper, we examine trends in the efficiency of one of the early LMP markets, the New York Independent System Operator (NYISO), analyzing a panel data set of over 9000 contracts over a six-year period beginning September 2000. We show that NYISO FTR markets were inefficient in their early years, but that market participants learned to predict forward prices and thus efficiency improved for FTRs not solely within the New York City/Long Island sub-region. FTRs within this sub-region, which has a number of special characteristics, remain relatively inefficient.

1. Introduction

The design of effective market mechanisms for electric power has presented significant challenges for economists. Central to the problem of electricity market design is the allocation of scarce transmission capacity. Because electricity cannot be easily stored, generation and demand for power on the grid must be kept within a close tolerance at all times. Moreover, the production and transmission of alternating current (AC) power is subject to a number of intertemporal and spatial constraints, given existing thermal power plant technology and the limitations of power flows on the grid (Schweppe et al., 1988). The constraints make it difficult to define tradable property rights for transmission. This difficulty has led economists to instead create markets for Financial Transmission Rights (FTRs). Our goal in this paper is to examine the efficiency of the New York Independent System Operator (NYISO) market for FTRs, one of the earliest FTR markets to be established.

The paper proceeds as follows. We first describe the various approaches that have been used to solve the problem of pricing transmission capacity and then describe the approach used in the NYISO market. In Section 2, we describe the market design problem and review the prior literature. In Section 3, we describe the econometric approach to testing hypotheses about market efficiency, risk premia, and learning. We also describe the data set used to estimate the model coefficients. Section 4 presents results. We conclude in Section 5 and offer suggestions for further research.

1.1. Explicit and implicit pricing of transmission capacity

In the developed world, the pricing of transmission capacity tends to incorporate either an explicit or an implicit framework. In European countries, the explicit auctioning of transmission capacity, separate from energy markets, is common. However, coordination of these auctions across regions can be problematic. A completely decentralized set of explicit auctions in an interconnected grid, for example, is unlikely to be fully efficient because the transmission capacity available across one path of the grid may depend on flows elsewhere on the grid. Even if these problems are addressed, separate pricing of energy and transmission (which in many circumstances have strong substitution and complementary characteristics) can undermine efficiency in the underlying local energy commodity markets.

Thus, it makes sense that the European Union is fixing increasing attention on the implicit pricing of transmission capacity, following trends in market design in the United States (Duthaler and Finger, 2009). Under an implicit market coupling approach, energy and transmission are priced together, in a single market mechanism that recognizes the interrelationships between the energy and transmission markets and clears both simultaneously. Within this implicit pricing context, transmission rights are most commonly defined as financial

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transmission rights or FTRs. An FTR does not provide any physical right to flow power across a transmission interface, but rather provides a hedge against the locational price differences created under an implicit market coupling approach. Because the FTR is a purely financial contract, the transmission system operator (TSO) continues to control all transmission capacity and can allocate it efficiently in real-time to meet load.

The locational marginal pricing (LMP) model that is used in the Northeastern and Midwestern United States and is scheduled to be introduced into Texas and California, is an extension of the implicit market coupling approach. The essence of the LMP approach is that all operational decisions are made by the grid operator and that power produced and consumed is traded at the locational spot power price. All significant transmission constraints are reflected in the unit commitment and dispatch models run by the TSO and are reflected in locational prices. Thus, at every major point on the grid, an array of different spot power prices is used for settling energy transactions. The New York Independent System Operator (NYISO), along with Pennsylvania, New Jersey, Maryland (PJM), was one of the first LMP markets in the United States, having conducted periodic FTR auctions since November 1999. The NYISO markets calculate day-ahead and real-time LMPs at numerous points across New York State's power grid, which has a complex interconnected topology. For purposes of financial settlement, the NYISO markets implemented a system by which generators are considered to generate at their bus, while loads are considered to consume in a load zone. The NYISO grid is divided into 11 load zones–labeled “A” to “K” as shown in Fig. 1 below–plus 4 import zones that are used to price imports and exports to and from neighboring U.S. and Canadian markets.

Prices are denoted in dollars per megawatt-hour. For example, a generator who produces 100 MW for an hour at a specific node *x* within Zone A will be paid 100 times the node *x* price for that hour while a load at a specific node *z* of 10 MW in Zone J will pay 10 times the local price for that hour. The centrally coordinated spot market effectively clears all nodal markets simultaneously, taking account of loads, generation, and transmission constraints.

1.2. The structure of financial transmission rights markets in New York

Although this spot market system is effective at addressing the realities of power flow on an interconnected grid, on its own it poses substantial financial risks for both generators and users of power. Congestion prices are highly volatile, as Fig. 2 illustrates. This example shows the hourly congestion charge (per MWh) in each hour for a hypothetical bilateral transaction between the West Zone (Zone A) and New York City (Zone J) for one day in early July 2008.

Given the magnitude and volatility of congestion prices in an LMP market, some method is needed to hedge the price risks posed by spot power prices that vary from location to location and by hour. In response to this problem, Hogan (1992) proposed a system of financial hedging contracts designed to mitigate the component of this risk associated with congestion. These financial hedging contracts–fundamentally similar to financial swaps–pay the owner of the congestion contract the quantity (in MW) times the congestion price difference between a specified Point of Injection (PoI) and Point of Withdrawal (PoW) for each hour in the term of the contract. These FTRs (which are called transmission congestion contracts or TCCs in the NYISO) play the role that ordinary point-to-point transmission rights play in physical market designs, although in this case they act solely as financial swaps and have no direct effect on system operations.

For example, a monthly FTR might be defined with a PoI of Albany and a PoW of New York City. For each hour in the month, the FTR holder is paid the difference between the NYC and Albany congestion prices. The LMPs in New York also include a locationally specific marginal loss component. This element of the LMP is not included in the TCC structure and is not considered in the present analysis. FTR payments over an hour (or longer periods) can be negative — an FTR is an obligation to pay the sum of congestion price differences even if this sum is negative.

Hogan has shown that the merchandizing surplus obtained by the grid operator in the energy market is sufficient to fund a full set of FTRs that reflect the maximum physical simultaneous transfer capability of the transmission grid (Hogan, 1992). If the TSO therefore auctions or allocates no more FTRs (in megawatt terms) than it can reliably sell as physical transmission rights, its energy transaction surplus in the day-ahead market will be sufficient to pay the aggregate congestion price differences to FTR holders. This result has had a substantial impact on modern electricity market design and underlies the FTR auctions that occur in the NYISO market and elsewhere in the U.S.

NYISO has conducted periodic FTR auctions since November 1999. Market participants include generators, transmission owners, and marketers, including financial participants such as investment banks. In New York, FTRs are sold for varying durations — 1 month, 6 months, or 1 year. As described above, a one-month FTR is the right to hourly differences between congestion prices at two specified locations for the period of a calendar month. Since the FTR is defined as an obligation, and not an option, it may have a negative value, in which case a reverse auction is used to allocate it. Both positive and negative FTRs are allocated in the same auction. An auction of FTRs covering a month is conducted early in the preceding month, so that a FTR covering the month of November, for example, will be auctioned in early October. We focus on the monthly FTRs, which by design are never overlapping in coverage, in order to avoid statistical issues associated with overlapping observations.

2. Efficiency of transmission rights auctions

By providing for the optimal use of the transmission grid, supporting least-cost system dispatch, and minimizing total system costs, the productive efficiency of the LMP and FTR-based market design offers considerable economic advantage (CRA, 2008). The use of FTRs settled against day-ahead locational spot prices allows price risks to be hedged separately from system operations. This arrangement allows the TSO to centrally dispatch all generation units to meet transmission reliability constraints at least-cost and determine hourly marginal prices for all loads. Short-run productive efficiency is thus improved.

However, concerns over potential inefficiencies in the FTR mechanism are twofold. First, even in LMP markets, the majority of trade is in (bilateral) forward markets, which are traded on expectations of future locational spot prices. Market participants must be able to form reasonable expectations of future locational prices if forward market liquidity is to be maintained and the allocative efficiency of forward prices is to be preserved. FTR pricing–in the periodic auctions and secondary markets–should, in theory, provide a means of price discovery about future transmission congestion and price levels. If price discovery is poor, then the market to allocate transmission capacity may be less efficient. Second, the FTR auctions made by NYISO and the other system operators forms part of the process through which the merchandizing surplus is returned by the TSO. If the prices paid in the auctions do not reflect the full value of transmission congestion rents, this process may not be fully efficient.

2.1. Previous analyses of transmission market efficiency

Despite the importance of this topic and the wealth of empirical data emerging from NYISO and other electricity markets, relatively few analyses have addressed the efficiency of transmission markets. A relatively early paper, DeVany and Wall (1999), examined