Using Virtual Bids to Manipulate the Value of Financial Transmission Rights

by

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ABSTRACT

In this paper, we present a straightforward economic model that explains the incentives to manipulate nodal energy prices in a “Day 2” RTO market. The model distinguishes between legitimate market participation that increases overall market efficiency and manipulative behavior that distorts markets and reduces efficiency. The example we use is the placement of “virtual” load or supply to enhance the value of financial transmission rights. This model shows the incentives that drive a trader’s stand-alone decision to place virtual bids at a node, the change in those incentives if the trader also holds a FTR position tied to that node, and the potential profit-maximizing opportunity to lose money on the virtual bids to increase the value of the FTR position and overall portfolio. We show that intentional uneconomic trading of virtual bids to trigger a manipulation causes the divergence of day-ahead and real-time nodal prices and thus creates market distortions and inefficiencies. This model also identifies the elements needed to successfully execute such manipulations, linking the analysis to a broader framework for detecting or rejecting market manipulation. These results explain past manipulations and should assist future efforts to detect and prove or disprove manipulative trading behavior within the RTOs, irrespective of whether such oversight derives from the FERC and/or the CFTC. They also provide guidance to both compliance and enforcement efforts on how to define legitimate behavior and avoid potentially manipulative behavior to the benefit of overall market liquidity.

* The authors’ comments are their own and do not necessarily represent those of others at The Brattle Group or the firm’s clients.
I. Introduction

The Energy Policy Act of 2005 (EPAct)\(^1\) provided the Federal Energy Regulatory Commission (FERC) with a fraud-based anti-manipulation statute tied to the case precedent that underlies the SEC’s Rule 10b-5.\(^2\) Market manipulation “Rule 1c” was adopted by the Commission on January 19, 2006\(^3\) and gave the FERC the ability to prohibit the use of “any device, scheme, or artifice to defraud” the wholesale natural gas and electricity markets and to prosecute market participants who “engage in any act, practice, or course of business that operates or would operate as a fraud or deceit upon any [entity].”\(^4\) Through its Office of Enforcement—which consists of the Divisions of Analytics and Surveillance, Audits, Energy Market Oversight, and Investigations\(^5\)—the Commission has the authority under EPAct to order the disgorgement of profits\(^6\) and to assess civil penalties up to $1 million per incident, per day.\(^7\)

The extent of this power was demonstrated most dramatically in a $245 million stipulation and consent agreement signed between the Commission and Constellation Energy Commodities Group (CCG) on March 9, 2012.\(^8\) The Commission levied $135 million in civil penalties and $110 million in disgorgement based on findings that CCG entered “into virtual transactions and [day-ahead] physical schedules without regard for their profitability, but with the intent of impacting [day-ahead] prices in the NYISO and ISO-NE to the benefit of certain significant [contract for differences] positions held by CCG.”\(^9\) Key to this finding was a determination that the virtual trades placed by CCG were “uneconomic”—i.e., causing divergence of the day-ahead and real-time prices and thus losing money on a stand-alone basis.\(^10\) These trades were intended to move day-ahead prices, which increased the value of CCG’s financial transmission rights (FTRs) and other swaps targeted by the manipulation.\(^11\) Because the size of its FTR and swaps positions\(^12\) exceeded those of its virtual and other unprofitable trades, the resulting financial leverage allowed CCG to earn greater profits in its swaps than it lost in its virtual and physical trades, netting CCG a profit from its alleged scheme.

Additional Future Oversight by the CFTC

While participants in the Regional Transmission Organizations (RTOs)\(^13\) will no doubt be wary of the FERC’s most recent demonstration of its anti-manipulation authority, yet another source for concern as to anti-manipulation enforcement may derive from the Commodity Futures Trading Commission (CFTC). Specifically, pursuant to the Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank),\(^14\) the CFTC has suggested that some RTO-traded instruments, in particular FTRs, are swaps as defined by Dodd-Frank and thus fall under CFTC jurisdiction.\(^15\) Without ceding jurisdiction, the RTOs have filed for a public interest exemption

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\(^4\) *Id.* at P 1.
\(^6\) *Enforcement of Statutes, Order, Rules, and Regulations*, 132 FERC ¶ 61,216 at P 216 (2010).
\(^7\) 16 U.S.C. § 825o-1(b) (2006).
\(^8\) Constellation Energy Commodities Group, Inc., 138 FERC ¶ 61,168 (2012).
\(^9\) *Id.*, at P 12.
\(^10\) *Id.*, at PP 2, 8, 9, 12, and 17. See also FERC Chairman Wellinghoff’s advice concerning the message sent by the stipulation: “do not trade uneconomically on one position in order to benefit the value of another.” *Chairman Wellinghoff’s statement on the Constellation Energy Commodities Group Investigation*. available at http://www.ferc.gov/media/statements-speeches/wellinghoff/2012/03-15-12-wellinghoff.asp (March 15, 2012).
\(^11\) *Id.*, at PP 5 and 15.
\(^12\) *Id.*, at P 6.
\(^13\) We use the term RTO to represent all types of entities tasked with operating regional transmission systems in furtherance of wholesale competition, including Independent System Operators (ISOs).
\(^14\) P.L. No: 111-203 (July 21, 2010).
\(^15\) After the passage of Dodd-Frank, the CFTC questioned in a Notice of Proposed Rulemaking whether FTRs and other FERC jurisdictional instruments may inherently belong under CFTC jurisdiction, noting “the treatment of these products should be considered under the standards and procedures specified in Section 722 of the Dodd-Frank Act for a
from CFTC oversight, seeking exemptions for transactions involving FTRs, energy (including virtual trades), forward capacity, and ancillary services. However, this request explicitly did not seek the exemption of these transactions from the anti-manipulation provisions of Dodd-Frank, but rather welcomed joint oversight and enforcement authority from the CFTC in addition to continuing anti-manipulation oversight by the FERC.

Oversight under both the anti-manipulation rules of the CFTC and the FERC may raise three key concerns for market participants in the RTOs. First, the CFTC’s rules specifically include a prohibition of the creation of (or the attempt to create) an artificial price, a historically imprecise standard for evaluating manipulation that may consider behavior otherwise permissible under a fraud-based statute as manipulative. Second, the missions of the FERC and CFTC are sufficiently different that behavior seen by one agency as legitimate could be perceived by the other as manipulative. Third, the resolution of such potentially inconsistent or uneven enforcement issues presupposes a level of cooperation between the agencies that recent history suggests is absent. For these reasons, RTO market participants face significant regulatory risk and may rightfully seek guidance not only as to the types of behavior that may be considered manipulative by one or both of these agencies, but also a description of the types of behavior that are clearly not manipulative.

A Model to Distinguish Legitimate and Manipulative Behavior in Electricity Markets

To this end, we present in this paper a straightforward economic model that captures the incentive to influence nodal energy prices in a “Day 2” RTO and allows for the differentiation between manipulative and legitimate behavior of market participants. The example we use tracks the placement of virtual bids and their interactions with the value of FTRs. The model shows the incentives that drive a trader’s stand-alone decision to place virtual bids at a node and thus engage in legitimate trading behavior that increases market efficiency, the change in those incentives that results if the trader also holds a FTR position that ties to the node, and the trader’s profit-maximizing incentive to manipulate the market by losing money on its virtual bids to increase the value of its FTR position and overall portfolio. We demonstrate that the intentional placement of uneconomic virtual bids to trigger a manipulation of FTR values diverges day-ahead and real-time nodal prices and thus creates market distortions and inefficiency. This model also demonstrates the market characteristics most likely to enhance the probability of the manipulation’s success and ties the analysis herein to a generalized public interest waiver, rather than through this joint rulemaking to define the terms ‘swap’ and ‘security based swap.’”

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17 Id., pp. 5-9.


19 CFTC Manipulation Rule, 17 C.F.R. Part 180.2.

20 The FERC’s mission is to “Assist consumers in obtaining reliable, efficient and sustainable energy services at a reasonable cost through appropriate regulatory and market means.” See http://www.ferc.gov/about/strat-docs/strat-plan.asp.

21 The CFTC’s mission is to protect market users and the public from fraud, manipulation, abusive practices and systemic risk related to derivatives that are subject to the Commodity Exchange Act, and to foster open, competitive, and financially sound markets.” See http://www.cftc.gov/About/MissionResponsibilities/index.htm.

22 Specifically, behavior that is inconsistent with “just and reasonable” rates may have no bearing on the efficient functioning of markets (and vice versa).

23 For example, on April 25, 2012, the CFTC made a filing supporting Amaranth trader Brian Hunter’s challenge of the FERC’s jurisdiction to enforce an anti-manipulation action under Rule 1c. See Amanda Bransford, “CFTC Challenges FERC’s Authority To Fine Gas Trader $30M,” Law360 (April 26, 2012). Additionally, the Memorandum of Understanding (MOU) between the agencies required by Dodd-Frank, §§ 720(a)(1)(A), (B), (C) to be completed between the agencies as of January 11, 2011 has yet to be agreed to at the time of this writing.
manipulation framework we discuss in another paper. These results should assist future efforts to detect and prove or disprove manipulative behavior within a RTO irrespective of whether such oversight derives from the FERC or the CFTC. It also informs trading companies’ compliance efforts in their efforts to define and avoid potentially manipulative behavior.

The remainder of this article consists of six sections. Section II explains the function of virtual bids within Day 2 RTOs. Section III models the stand-alone incentives that underlie a trader’s decision to place such bids. Section IV explains the role and function of FTRs in Day 2 markets and discusses their potential manipulation through virtual bids. Section V then employs a simple model to demonstrate a trader’s incentive to place an excessive quantity of virtual bids into the market to manipulate the value of its FTR position. This presentation identifies market conditions that allow for successful manipulations and shows that the approach used herein is a specific application of a more general framework for analyzing manipulations. Section VI discusses the degradation of market efficiency caused by the placement of excessive virtual bids to manipulate FTR values, providing a yardstick by which to distinguish manipulative behavior from legitimate trading. This distinction could bring much needed clarity to enforcement and compliance efforts under the auspices of future RTO market oversight by the FERC and CFTC. Finally, Section VII presents our conclusions.

II. The Function of Virtual Bids and Offers within Day 2 RTOs

“Day 2” wholesale power markets use a bifurcated market design wherein physical power is competitively traded in an hourly day-ahead market (DAM) designed to optimize supply to meet forecasted load and a real-time market (RTM) wherein electricity is traded to balance the system for variances from the planned day-ahead dispatch. Power is traded at numerous “nodes” throughout each RTO system, which may be aggregated into trading hubs or zones. The price of power at each node (referred to as the locational marginal price or “LMP”) varies depending upon the system energy price, the cost of transmission losses incurred in serving the node, and the “congestion” cost created through transmission constraints encountered in supplying power at that node. Given the innate complexities associated with managing the physical operation and economic optimization of a transmission grid, significant and unexpected variability can emerge between the day-ahead and real-time LMPs at particular nodes as well as across nodes. Each RTO offers instruments designed to hedge against or profit from the risk associated with such price differentials. While some products such as FTRs are price-taking, others (including virtual bids) can influence electricity prices and thus be used for manipulative purposes.

Traders participating in Day 2 wholesale electricity markets use virtual demand bids (also known as “decremental bids,” “DECs,” or “virtual load”) and virtual supply bids (also known as “incremental bids,” “INCs,” or “virtual supply”) to statistically arbitrage expected differences between day-ahead and real-time prices. Virtual bids simultaneously clear with bilateral and other physical trades and therefore will tend to impact day-ahead and (at times) real-time LMPs. The distinguishing characteristic of a virtual trade is that the quantity of megawatts (MW) bought or sold by the trader in the DAM is exactly offset by a sale or purchase of an identical quantity in the RTM, such that the net effect on the physical market quantity traded is zero. For example, if in a given hour a trader expects the day-ahead LMP at a point to exceed the real-time LMP at that point, it would offer virtual supply at that point for that hour. If the offer clears, the trader would receive the day-ahead price on all MW “sold” and pay the real-time price for the same number of MW “purchased,” netting

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25 For further discussion of the roles which virtual trades play in Day 2 RTOs, see Metin Celebi, Attila Hajos and Phil Hanser, “Virtual Trading: The Good, the Bad and the Ugly,” 23 The Electricity Journal 16, 20 (June 2010). Note that as a convention in this paper we attribute the determinative characteristics of “price taking” and “price making” to the instruments traded as opposed to the traders executing such instruments.

26 Virtual bids are allowed in all U.S. RTOs with a “Day 2” market design. Market participants can also place “synthetic” virtual bids using other types of transactions, such as scheduling to sell power into a region in the day-ahead market then cutting that schedule in the real-time. These “no-flow” transactions are functionally identical to virtual bids and are executable between RTOs and in markets that do not have a Day 2 market design.
a profit or loss equal to the difference of the day-ahead and real-time prices multiplied by the quantity of MW cleared. In essence, the trader uses the day-ahead market to sell to itself in the future real-time market such that the net effect is that of a purely “financial” transaction.

The Price Impacts of Virtual Trading

Despite the trader’s perspective, characterization of the effect of virtual bids on the day-ahead and real-time markets as purely “financial” is erroneous because they influence LMPs and can affect physical power flows. For example, in each hour and for each pricing point, a RTO could choose to use the higher of the summed demand forecasted by the load serving entities (LSEs) in the market, the LSE forecasted loads plus the net virtual demand in the market (equal to cleared DECs less cleared INCs), or the load forecasted by the RTO. Adding virtual bids to the day-ahead load will therefore affect the day-ahead price and could affect the real-time price if the bids affect the RTO’s physical commitment of generating units. To demonstrate this phenomenon, consider the representation of the day-ahead market shown below in Figure 1.

Figure 1

The Price Effect of Virtual Load on the Day-Ahead Market

For each hour, net virtual trades (VT) add to the demand forecast for load (DL) if the quantity of DECs exceeds the quantity of INCs. This raises the price in the DAM from P₀ to P₁ and increases the amount of generation resources procured by the RTO from MW₀ to MW₁. Since these resources will be available to the real-time market, the virtual bids may also affect real-time prices. Because the placement of virtual bids can affect the dispatch of real-time physical capacity, it is therefore inaccurate to characterize their impact as solely financial in nature.

Notwithstanding this observation, there is a clear price effect which virtual bids exert on the day-ahead market. As Figure 1 shows, DECs tend to raise prices in the day-ahead market while INCs tend to lower day-ahead prices. The converse can be true in the real-time market. The concave nature of the offer curve accentuates these pricing effects in power markets. Thus, as load increases, each MW of successive clearing DECs bids will have an increasingly powerful effect on price. The reverse is true for successive INCs, as the first INC negates the last (most powerful) DEC and subsequent INCs negate demand with less and less price impact.

27 Note that use of the maximum of these three calculations mandates that net short virtual positions (when the number of INCs cleared exceeds the number of cleared DECs) will not be considered in the DAM. This is consistent with procuring a sufficient supply needed to preserve reliability in the market.

28 One could argue that because real-time dispatch is independent of all load forecasts, virtual bids should not affect real-time prices. However, because the RTO prepares physical generation for dispatch to meet virtual load, the failure of that load to materialize could logically serve only to decrease the real-time price unless the RTM is operating in a perfectly elastic region of the of the real-time offer curve. Whether this price effect manifests itself through the real-time LMP or through a different pricing mechanism (such as “uplift” charges) is irrelevant to this presentation, assuming such charges transparently tie back to their associated virtual trades. See Celebi et al., supra note 25 at 21.
The Role of Virtual Trading in Price Convergence

The main benefit cited in support of the use of virtual transactions derives from their tendency to equilibrate the prices between the day-ahead and real-time markets. To demonstrate this, consider a numeric scenario wherein a virtual trader expects the day-ahead and real-time LMPs at a node to be $30/MW and $70/MW, respectively. This is represented in Figure 2. The trader would place a virtual bid at that node for that hour, paying the day-ahead price on all MW purchased and receiving the real-time price for an identical number of MW sold. However, the act of buying MW in the day-ahead market tends to push the LMP in that market up from $30, while the act of reversing the transaction in the real-time market can push the price down below $70. As long as a differential exists, some trader in the market will have the incentive to continue to place virtual bids until the day-ahead and real-time LMPs are equal. For this reason, virtual trading is known as “convergence bidding,” as a competitive virtual market should tend to cause the day-ahead and real-time prices to converge in each hour.29

Figure 2

The Convergence Principal of Virtual Bidding

Because convergence of day-ahead and real-time prices mitigates market power and improves the efficiency of serving load, virtual trades not only affect market prices but also have a physical impact on the operations of the RTO and upon market participants that physically transact at the LMPs set in the day-ahead and real-time markets.30 The act of creating convergence acts against the self-interest of virtual traders, as the revenue from all virtual trades will be zero if the day-ahead and real-time prices are equal. In the presence of transactions costs, traders should therefore be averse to placing excessive virtuals for fear of incurring losses. The resulting corollary is that if a trader places virtuals beyond the point of convergence, they will lose money on the entire lot. In that case, the trader would be diverging the day-ahead and real-time LMPs, thereby creating inefficiency in the market. The choice by a trader to continually place virtual bids or offers in a manner that

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29 See Order [G]ranting [sic] Motion for Extension of Time And Addressing Convergence Bidding Design Policy Filing (130 FERC ¶ 61,122 [February 18, 2010]). Figure 2 shows that real-time prices fall as a result of the cleared DEC, which may or may not be the case given the RTOs’ method for dispatching its system. However, it is ultimately irrelevant to the analysis herein as to whether virtuals actually affect real-time prices because the placement of DECs will continue as long as a spread between the day-ahead and real-time prices exists; if real-time prices are unaffected by the virtuals placed in the example, the $40 spread will be reduced to zero at a price of $70 instead of a price between $30 and $70 as shown. See also Celebi et al., supra note 25 at 18-19.

30 For further discussion of the merits of convergence bidding, see the California ISO’s filing Convergence Bidding Design Policy (FERC Docket No. ER10-300-000 [November 20, 2009]).
tends to lose money therefore raises concerns that the trader may be attempting to trigger a manipulation by moving LMPs to accentuate the value of price-taking financial positions tied to the market prices.31

III. A Model of the Economic Decision to Place Virtual Bids

The following presentation generalizes the principles shown in Figure 2 to model a trader’s stand-alone incentive to bid virtual load (DECs) in a single hour at a single node. For every MW of DEC bids that clear, the trader will pay the day-ahead LMP “$P_{DA}$” and receive the real-time LMP “$P_{RT}$” at that node for that hour. It is rational for the trader to bid its first DEC into the market only if it initially expects that $P_{RT}^0 > P_{DA}^0$. Thus, using Figure 2 as an example, if the trader expects the initial day-ahead price to be $30/MW and the initial real-time price to be $70/MW, a one MW DEC would garner about $P_{RT}^0 - P_{DA}^0 = 70 - 30 = 40$.32 If the trader then bids more DECs into the market, all cleared bids will make money if $P_{RT} > P_{DA}$, a condition Figure 2 shows grows less likely with each additional MW of DEC cleared because the day-ahead and real-time prices then tend to converge.

To understand the trader’s decision making as to the quantity of DECs it should bid into the market to maximize profits on a stand-alone basis, we first present a model which assumes a single trader bids virtual load in the quantity of “$X$” MW at a single pricing location without any competition from other traders. This model demonstrates that the continual placement of DECs ultimately causes the day-ahead and real-time prices to converge (at $P_{DA}^C = P_{RT}^C$ in Figure 2), thus yielding no profit to the trader. The trader therefore has an incentive to bid an amount of DECs designed to cause partial convergence, allowing it to profit from the remaining spread on all MW cleared. Following the discussion of the simplified market, we adapt the single-trader model to consider the outcome that results if multiple traders are able to place virtual bids and offers into a competitive market. The resulting movement toward convergence produces the efficiency gains associated with virtual bidding, as the coordination of day-ahead and real-time pricing through statistical arbitrage simultaneously minimizes a source of uplift and neutralizes pricing variances caused by the use of market power.

Profit Maximization for a Single Trader of Virtual Bids

Assume that a single trader can choose the quantity of DECs (in the amount of “$X$” MW) that it will bid in a single hour at a single node. Based on the logic of Figure 2, the trader can develop a derived demand curve for its virtual bids given the expected price spread ($P_s$) between the real-time and day-ahead prices assuming different quantities of DECs clear ($P_s = P_{RT} - P_{DA}$). Given the inverse relationship between the spread paid to DECs and the total quantity of DECs that clear, the demand for virtuals is downward sloping, with a vertical intercept at a price equal to $P_s^0 = P_{RT}^0 - P_{DA}^0$ and a horizontal intercept at the quantity of DECs “$X_{max}$” that creates price convergence ($P_{DA}^C = P_{RT}^C$, thus $P_s^C = P_{RT}^C - P_{DA}^C = 0$). For simplicity, this demand function is represented as linear and is shown in Figure 3.33

31 A trader may have a legitimate purpose in its willingness to persistently take losses on virtual trades. For example, the owner of generation might be willing to consistently lose money on a DEC bid at a generation source to hedge the possibility of outages during peak periods. However, if the virtual market is competitive, other traders should see the profit opportunity afforded by the divergence and bid INCs to restore convergence to the market.

32 Note that this is the trader’s expected profit based upon its own private information set, which may or may not prove to be correct once the day-ahead and real-time markets actually clear. Indeed, it is possible that the trader could lose money on this trade if its information is incorrect, making the transaction appear “uneconomic.” The model we provide herein is designed to assist efforts to distinguish losses incurred through legitimate trading from those anomalously incurred to trigger a manipulation.

33 More realistically, the derived demand has a non-positive slope with horizontal segments occurring intermittently due to portions of the day-ahead and real-time offer curves where blocks of generation are offered at a constant price. Subsequent analysis in Section V will consider the negative region of this demand curve beyond the point of convergence,
The clearing of successive DECs (and resulting movement down the demand curve) has two countervailing effects on the trader’s revenues. By successfully bidding each additional MW of DEC into the market, the marginal sale brings added revenue to the trader. However, the additional DEC sold simultaneously causes greater convergence between the day-ahead and real-time prices, thus reducing the revenues obtained across the entire lot of DECs bid by the trader. The “Marginal Revenues of Virtual Trades” curve in Figure 3 illustrates this combined effect. Marginal revenues are positive up to $X^*$, the point where the gain from the last MW bid exactly offsets the loss caused by price convergence across the lot of all DECs bid previously. Beyond $X^*$, the losses from convergence exceed the incremental value of each one MW sale, such that marginal revenues are negative. Assuming transactions are costless, the total profit made by the trader is the sum of the marginal revenues across all MW of DECs that clear, shown in Figure 3 by the “Total Revenues of Virtual Trades” curve. As the trader bids successive DECs up to $X^*$, each additional MW that clears adds positive revenues to the trader’s book. Beyond $X^*$, Total Revenues will decline at an increasing rate due to increasing losses caused by convergence. Because the single trader does not face competition from other traders and is solely interested in maximizing the total revenues derived from its virtual trades, it will therefore bid DECs in the amount $X^*$ and earn $TR^*$ as a profit.

Table 1 combines the information presented in Figures 2 and 3 in an algebraic construct. The trader is assumed to expect the pre-DEC spread between the real-time and day-ahead prices to be $40 and expects that convergence will occur if 40 MW of DEC clear. If the derived demand is linear, the trader’s demand for DECs is $P_s = 40 - X$, where “$P_s$” is the difference in the day-ahead and real-time prices given the quantity of DECs wherein the trader’s decision to place DECs is based on a joint portfolio of virtual bids and a FTR. The analysis also will be generalized mathematically to extend the model’s flexibility beyond the linear case.
that clear, “X” is the quantity of DEC MW bid by the trader that clear, and 40 is the pre-DEC spread corresponding to the vertical intercept \( P_{DA}^0 - P_{RT}^0 \). Assuming the trader then bids DECs (which, by assumption, clear) in five MW increments, the calculations shown in Table 1 result. The trader maximizes total revenues by bidding 20 MW of DECs into the market and driving the day-ahead/real-time spread to $20 per MW, corresponding precisely with the profit maximizing quantity of bids \( X^* \) and resulting price spread \( P_2^* \) the presentations of Figures 2 and 3 anticipate.

### Table 1

**Profit Maximization of Virtual Bids Placed by a Single Trader**  
(No Competition from Other Traders)

<table>
<thead>
<tr>
<th>Location on Horizontal Axis</th>
<th>Real-Time vs. Day-Ahead Price Spread ((P_S = 40 - X))</th>
<th>Quantity of DEC MW Cleared (X)</th>
<th>Total Revenues from Virtuals (TR = P_S \cdot X)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Origin ((0))</td>
<td>40</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>5</td>
<td>175</td>
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<td></td>
<td>30</td>
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<td>300</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>15</td>
<td>375</td>
</tr>
<tr>
<td><strong>Maximized Revenues (X^*)</strong></td>
<td><strong>20</strong></td>
<td><strong>20</strong></td>
<td><strong>400</strong></td>
</tr>
<tr>
<td></td>
<td>15</td>
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<td>175</td>
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<tr>
<td><strong>Convergence (X_{max})</strong></td>
<td>0</td>
<td>40</td>
<td>0</td>
</tr>
</tbody>
</table>

A generalized method for determining the optimal stand-alone quantity of DECs that the virtual trader should place to maximize revenue derives from Equation 1:

\[
P_S = P_{RT} - P_{DA}. \tag{1}
\]

Specifically, because DECs \(X\) tend to raise day-ahead and (possibly) lower real-time prices,

\[
\frac{\partial P_{DA}}{\partial X} \geq 0, \quad \frac{\partial P_{RT}}{\partial X} \leq 0, \tag{2a}
\]

so convergence occurs such that

\[
\frac{\partial P_S}{\partial X} = \frac{\partial P_{RT}}{\partial X} - \frac{\partial P_{DA}}{\partial X} \leq 0. \tag{2b}
\]

The trader’s total revenues from its virtual trading then equal cleared DECs times the spread, and these revenues are maximized where the marginal revenues from trading equal zero:

\[
TR = P_S \cdot X = \left(P_{RT} - P_{DA}\right) \cdot X = P_{RT} \cdot X - P_{DA} \cdot X \quad \Rightarrow \quad \frac{\partial TR}{\partial X} = \frac{\partial P_{RT}}{\partial X} \cdot X + P_{RT} - \frac{\partial P_{DA}}{\partial X} \cdot X - P_{DA} = 0 \quad \Rightarrow \quad \tag{3a}
\]

\[
MR = \frac{\partial TR}{\partial X} = \frac{\partial P_{RT}}{\partial X} \cdot X + P_{RT} - \frac{\partial P_{DA}}{\partial X} \cdot X - P_{DA} = 0 \quad \Rightarrow \quad \tag{3b}
\]

\(^{34}\) Since Demand is given by \(P_S = 40 - X\), Total Revenues \((TR) = P_S \cdot X = (40 - X) \cdot X = 40X - X^2\) and Marginal Revenues \((MR) = \frac{\partial TR}{\partial X} = 40 - 2X.\)
\[
\left( \frac{\partial P_{RT}}{\partial X} - \frac{\partial P_{DA}}{\partial X} \right) \cdot X = P_{DA} - P_{RT} \Rightarrow \quad (3c)
\]

Substituting Equations (1) and (2b):
\[
\left( \frac{\partial P_S}{\partial X} \right) \cdot X = - \left( P_S \right) \Rightarrow \quad (3d)
\]

\[
X^* = - P_S \cdot \frac{\partial X}{\partial P_S} > 0 \bigg| \frac{\partial X}{\partial P_S} < 0 \quad (3e)
\]

Thus, for the linear demand curve used in the previous example where the initial price spread is $40/MW and the inverse of the slope of the demand curve is negative one, \( X^* = -(20)(-1) = 20 \) MW of DEC.

**Convergence in the Presence of Multiple Traders of Virtual Bids**

The previous discussion assumes that only one trader bids DECs into the market, yielding a bid of \( X^* \) DECs that will not fully converge the prices of the day-ahead and real-time markets upon clearing \( (P_S^* > 0) \). However, assuming sequential bidding,\(^36\) there is an incentive for another trader to enter the virtual market and bid DECs to take advantage of the remaining price spread associated with \( P_S^* \). In the context of Table 1, the second trader will observe that there remains a $20 spread in the market after the first trader’s bids clear. The second trader’s residual demand for DECs is then \( P_S = 20 - X \), prompting it to maximize revenues by bidding 10 MW of DECs. If these clear, the total number of DECs in the market will then be 30 and the resulting spread will fall to $10. Continuing in this sequential bidding paradigm, other traders would then opportunistically bid for the remaining surplus, moving the market toward a total quantity of DECs trades equal to \( X_{\text{max}} \) and bringing convergence of the day-ahead and real-time prices towards the transaction costs of virtual trading. This process typifies arguments of why virtual bids contribute to market efficiency. Because physical capital is not required to participate in the virtual market, a multitude of traders can participate and use virtuals to eliminate the market inefficiency that would exist if only physical entities or single virtual bidders were able to trade.

**IV. Financial Transmission Rights and the Incentive to Influence Day-Ahead Prices**

FTRs allow customers to protect against the risk of congestion-driven price increases in the DAM for transmission service in the RTOs. Congestion costs occur as the demand for scheduled power over a transmission path exceeds that path’s flow capabilities. For example, if the transmission capacity going from Point A (the “source”) to Point B (the “sink”) is 500 MW, but the RTO seeks to send 600 MW of power from Point A to Point B when calling on the least-cost generators to serve load, congestion occurs on the path. This causes the congestion price at the source \( (CP_{DA}^{\text{Source}}) \) to decline and the congestion price at the sink \( (CP_{DA}^{\text{Sink}}) \) to increase, raising the cost of serving Point B from Point A to a level at which the RTO can economically limit power flows to the available 500 MW of transmission capacity. By obtaining a FTR (of a size of “F” MW) over the path from Point A to Point B, the FTR holder receives \( (CP_{DA}^{\text{Sink}} - CP_{DA}^{\text{Source}}) \times F \), the difference of the congestion prices between the sink and source, thus allowing it to hedge against the congestion charges it would otherwise incur in the day-ahead market. FTRs were originally developed to give traditional utilities and other load serving entities (LSEs) price certainty similar to what was available to traditional vertically-integrated utilities prior to the introduction of market-based congestion management. This practice continues, as FTRs (or

\(^{35}\) While a change in the quantity of DECs traded could result in no change in price (indicating transactions occurring within a horizontal region of the demand curve), any change in price must necessarily be caused by a change in the quantity of DECs traded.

\(^{36}\) For simplicity, this presentation assumes that traders place bids sequentially. This is clearly not the case since the DAM and RTM follow an auction format. Auction theory would nevertheless predict an outcome equivalent to this result if competitive market conditions prevail, as is the pretext for allowing virtual bidding in the first place.
“auction revenue rights” that are convertible into FTRs) are allocated to LSEs and to other entities that fund the construction of specific new transmission facilities in the Day 2 RTOs.

Although FTRs are used by LSEs as a hedge, they can also be purchased by any creditworthy entity seeking their financial attributes as a risk management tool or a speculative investment. In this regard, FTRs are simply financial instruments executed as contracts for differences between the day-ahead prices at two locations. While sharing many attributes, FTRs differ from “swaps” because the physical constraints of the transmission grid limit the available quantity of FTRs and because swaps generally tie to the total LMP at a node, not its congestion component. As to the first point, RTOs limit the quantity of FTRs made available based on a simultaneous feasibility test performed across all potential transmission constraints, which limits the size of the net positions that can be held by market participants.37 By comparison, because financial swaps have no physical dimension, traders can accumulate swaps in quantities bounded only by the willingness of counterparties to take an opposing financial position. Concerning the second point, FTR payments are based only upon the congestion component of day-ahead LMPs, whereas swaps can be based upon the total LMP or any components thereof.38

Because FTRs and other types of instruments designed to allow market participants to hedge congestion are price-taking in the day-ahead market, there is legitimate concern that market participants with FTR positions of sufficient size may have incentives to manipulate day-ahead market prices in an effort to benefit their FTR positions.39 For this reason, it is relevant to consider the three sources through which market participants can acquire FTRs and similar congestion revenue rights: through direct allocations from the RTO; through positions purchased in RTO auctions; and through bilateral purchases such as those facilitated through the ISO-NE “bulletin board.”40

Allocated Congestion Rights

All Day 2 RTOs allocate some of the available congestion revenue rights to the load-serving entities within their markets. In PJM, MISO and ISO-NE, these are allocated as Auction Revenue Rights (ARRs), which give their holders the right to either receive FTRs or the revenues raised from selling the FTRs in the various auctions. Conversely, the CAISO and ERCOT allocate Congestion Revenue Rights (CRRs), which provide their holders with payments based on the actual congestion occurring on associated paths. Finally, the NYISO allocates both auction-based and congestion-based rights through a number of instruments designed to compensate transmission owners and hedge the load-serving entities protected by standard FTR products, called Transmission Congestion Contracts (TCCs). PJM and MISO allow ARR holders to convert all of these rights to FTRs. By comparison, the NYISO allows only 5% of ARR-equivalent instruments to be converted to TCCs. ISO-NE does not allow such conversions, while CAISO and ERCOT allocations of CRRs are already in a form equivalent to FTRs. Converted ARRs are fully fungible in PJM, the MISO, and NYISO. CAISO only allows the sale of allocated CRRs in its secondary market, while ISO-NE has no converted instruments to sell.

37 Note that participants in FTR auctions can procure “counter flow” capacity which directly offsets “prevailing flow” FTRs, thereby allowing the value at risk on a given path to exceed the physical limits of the line. However, such bids are ultimately physically constrained, as the net position held on the path should always conform to the simultaneous feasibility test.

38 At a given node for a given hour, the total day-ahead LMP ($P_{DA}$) consists of an energy component (equal to the marginal cost of the last generation unit used to serve load), a loss component (equal to the marginal transmission losses incurred in serving the node), and the congestion price ($CP_{DA}$). While FTRs tie exclusively to the latter component, swaps bear no such restrictions. See http://www.nodalexchange.com/products_and_services/overview.php. The distinction between the total LMP and its congestion component is relevant to the discussion of Sections V and VI concerning the manipulation of FTRs using virtual bids, because virtual bids are paid based on the total LMP whereas FTRs are paid based only on the congestion price.

39 See Celebi et al., supra note 25, pp. 20-23.

Auctioned Congestion Rights

All Day 2 RTOs provide FTRs (or equivalent products, such as CRRs or TCCs) for sale to market participants through auctions held at various times of the year. The RTO auction process includes an annual (or multi-year) auction of one-year FTRs and monthly or quarterly auctions of shorter-term FTRs supplied by existing FTR holders or made available by the RTO. The auctions are scheduled and performed by the RTO, which requires bidders to post credit sufficient to cover the positions taken. The products sold vary by market and by auction, with some products made available only at specific auctions. For example, the NYISO sells monthly TCCs exclusively in its monthly auctions and sells annual and semi-annual TCCs only in its semi-annual auctions. FTR holders are typically allowed to resell portions of their holdings in the auctions; for example, the holder of a quarterly FTR in MISO can sell any of the associated three months of that FTR in a later monthly auction. Auction data concerning cleared bids is publicly available in the six RTOs. Note that in addition to traditional FTRs, PJM allows auction market participants to bid on both prevailing flow and counter flow FTR options that allow their holders to exercise the right to payment only if the underlying FTR is profitable.

Bilateral FTR Markets

Most RTOs operate a venue designed to enable bilateral trading for FTRs among market participants. Such bilateral trading has raised concerns that those participants intent on market manipulation could use these systems to execute off-market FTR transactions to evade reporting requirements to the RTOs and the FERC. However, because congestion payments are made directly from the RTO to the FTR owner of record, there is no validity to this concern. Further, these platforms have experienced little historical volume, likely because participants can secure FTRs through the RTO auctions and can trade FTR-equivalent financial swaps through other sources. Swaps offer traders the ability to avoid the credit and reporting requirements associated with FTR ownership, features which make them attractive as potential manipulation targets. Indeed, the ability of a manipulator to combine a FTR position with bilaterally acquired swaps (as was alleged of CCG) presents a significant concern, as the additive net position created therefrom may provide a would-be manipulator with large financial leverage that is undetectable given the historical limits of the FERC’s and CFTC’s regulatory authority.

Whether used as a hedge or held as a speculative investment, it is in the interest of a RTO to allow all qualified market participants to bid in the auctions and procure FTRs because robust participation funds the auction revenue rights paid to LSEs. However, the holders of large FTR positions (or equivalent positions in financial swaps) may have the incentive to purposely enhance those positions’ value using transactions that affect day-ahead LMPs, such as virtual bids. If there is evidence that a trader is consistently engaging in uneconomic virtual trades at specific locations, the behavior may be an attempt to set prices to benefit the value of the trader’s related price-taking positions—thereby triggering a manipulation. To understand the incentives that drive such behavior, we next add FTRs to the trader’s virtual trades to extend the analyses of Figure 3 and Table 1 to examine the trader’s joint decision-making process.

V. The Effect of Placing Virtual Load Bids at the Sink of a Prevailing Flow FTR

A prevailing flow FTR pays its holder the difference of the day-ahead congestion charges at the FTR’s sink and source, thus hedging the holder against the cost of increased congestion at the sink (or, less likely but conceivably, a glut of supply at the source). The effect of virtual load bids (i.e., DECs) at a sink tends to worsen congestion in the DAM at that point, causing the day-ahead congestion price differential to increase and the resulting value of the FTR sinking at that point to increase.41 For simplicity, the relationship between the quantity of DECs cleared and the resulting effect on the day-ahead price is assumed to be linear as shown below in Figure 4 by the line labeled “Enhanced Value of FTRs.”42

41 See Celebi et al., supra note 25, pp. 22-23.
42 Because the day-ahead offer curve is generally concave-up, every added DEC cleared will tend to increase the price at the sink, thus making this curve concave-up. Although a linear curve is used in this example for simplicity, this
The combination of the revenues from the FTR with those of the virtuals is shown as the curve labeled “Total Revenues: Virtual Trades + FTR Profits.” This curve achieves a maximum at a level of DECs \( (X^*) \) and a level of revenues \( (TR^*) \) above the DECs \( (X^A) \) and revenues \( (TR^A) \) of a trader bidding only virtual loads without the benefit of a related FTR position. The ability of a trader to enhance the value of its FTR therefore gives it the incentive to bid more virtual loads at the sink than it would absent the FTR. Specifically, assuming “F” MW of FTR, “X” MW of DECs, a price spread between the day-ahead and real-time of \( “P_S” \), and congestion prices at the FTR’s source and sink of “\( CP_{DA}^{Source} \)” and “\( CP_{DA}^{Sink} \)”, respectively:

\[
TR = P_S \cdot X + (CP_{DA}^{Sink} - CP_{DA}^{Source}) \cdot F \Rightarrow (4a)
\]

Substituting Equation (1):

\[
TR = (P_{RT} - P_{DA}) \cdot X + (CP_{DA}^{Sink} - CP_{DA}^{Source}) \cdot F \Rightarrow (4b)
\]

\[
TR = P_{RT} \cdot X - P_{DA} \cdot X + CP_{DA}^{Sink} \cdot F - CP_{DA}^{Source} \cdot F. \quad (4c)
\]
Assuming that the placement of DEC at the sink does not change the congestion price at the source, maximizing Equation (4c) obtains:

\[
MR = \frac{\partial TR}{\partial X} = \frac{\partial P_{RT}}{\partial X} \cdot X + P_{RT} - \frac{\partial P_{DA}}{\partial X} \cdot X - P_{DA} + \frac{\partial CP_{Sink}}{\partial X} \cdot F = 0 \quad \Rightarrow (4d)
\]

\[
\left(\frac{\partial P_{RT}}{\partial X} - \frac{\partial P_{DA}}{\partial X}\right) \cdot X = (P_{DA} - P_{RT}) - \frac{\partial CP_{Sink}}{\partial X} \cdot F \quad \Rightarrow (4e)
\]

Substituting Equations (1) and (2b):

\[
X^* = -\frac{\partial P_s}{\partial P_s} \cdot X - \frac{\partial CP_{Sink}}{\partial P_s} \cdot F \quad \Rightarrow (4f)
\]

Substituting Equation (3e) yields

\[
X^* = X^* - \frac{\partial CP_{Sink}}{\partial P_s} \cdot F. \quad (4h)
\]

Hence, given \( \frac{\partial CP_{Sink}}{\partial P_s} < 0 \) and \( F > 0 \), \( -\frac{\partial CP_{Sink}}{\partial P_s} \cdot F > 0 \) and therefore \( X^* > X^* \).

As Figure 4 demonstrates, the trader’s behavior yields a desirable result for the market; while \( X^* \) lies to the right of \( X^* \), it is below \( X_{max} \), the level of DEC needed to converge the day-ahead and real-time prices. As the goal of convergence bidding is for the market to supply an amount of DEC equal to \( X_{max} \), the trader can legitimately argue that any quantity of DEC it places such that \( X^* \leq X_{max} \) benefits the market, thus serving a legitimate purpose that should be above scrutiny for market manipulation.44

An efficient virtual bidding process also serves to mitigate any attempts at market manipulation. For example, if other market participants react such that the market collective always provides the net quantity of virtual trades associated with convergence at \( X_{max} \), the expected value of the trader’s FTR shown in Figure 4 must trend to FTR(\( X_{max} \)) irrespective of that trader’s actions. From this logic, it would follow that any attempt to manipulate day-ahead and real-time prices is futile since virtual bidding by others will mitigate attempts by individuals to exercise market power or disequilibrated those markets. Thus, a showing that a trader placed uneconomic virtual bids in a manner designed to enhance the value of its targeted financial position would be irrelevant, because the divergence caused by the manipulative strategy would invite opposing virtual bids that will restore convergence and thus thwart the manipulation.

Ignoring for the moment the flaw in the assumption that the competitive conditions needed for convergence are ubiquitous throughout the RTOs, a useful corollary emerges: in a perfectly efficient and competitive market, the expected value of a virtual trade is zero. Thus, while a fixed-size DEC placed at one location in any single hour may earn a significant profit or loss, placement of that DEC over time should result in offsetting gains and losses such that the trader’s cumulative profit should net to zero under competitive market conditions. Therefore, if a trader is discovered to consistently lose money on the virtuals it places over

\[43 \text{ Since } P_s = P_{RT} - P_{DA} \text{ and (by supra note 38)} \text{ } P_{DA} = CP_{ Sink} + P_{Energy} + P_{Losses}, \text{ it must be that:} \]

\[
\frac{\partial P_s}{\partial P_{DA}} < 0, \frac{\partial P_{DA}}{\partial CP_{Sink}} > 0 \quad \Rightarrow \quad \frac{\partial P_s}{\partial P_{DA}} \cdot \frac{\partial P_{DA}}{\partial CP_{Sink}} = \frac{\partial CP_{Sink}}{\partial P_s} < 0 \quad \Rightarrow \quad \frac{\partial CP_{Sink}}{\partial P_s} < 0.
\]

\[44 \text{ A savvy trader can use this to its advantage by placing DEC that are profitable on an accounting basis but that fail to cover its opportunity cost by not maximizing virtual bid revenues (i.e., } X^* < X^* < X_{max}) \text{. While such behavior could technically facilitate a manipulation, the agency seeking to prove it would likely need to demonstrate harm to counterparts and that an act benefiting the efficiency of the system and profiting the trader on a stand-alone basis nevertheless was executed to intentionally undercut the trader’s opportunity cost (the unobservable } TR^* \text{).} \]
time, the market cannot be perfectly competitive. This opens the possibility that the trader is strategically placing virtual trades in excess of \( X_{\text{max}} \) to benefit its related positions. The remainder of this section will demonstrate how this can occur by explaining how the trader could leverage losses in its virtual bids to trigger a manipulation of its targeted FTR position.

The Role of Financial Leverage in a Successful Manipulation

As the quantity of FTR megawatts exceeds and increases relative to the size of the virtual load bid at the FTR sink, the trader can “leverage” FTR gains against virtual trading losses. This may incent the placement of more DEC bids than necessary to create market convergence. If the quantity of FTR megawatts \( (F) \) exceeds the quantity of DEC megawatts associated with \( X_{\text{max}} \), the trader will set \( X^\gamma > X_{\text{max}} \) such that gains on its FTR will more than offset losses incurred on its virtual trades. From Equation (4e):

\[
\left( \frac{\partial P_{\text{RT}}}{\partial X} - \frac{\partial P_{\text{DA}}}{\partial X} \right) \cdot X = \left( P_{\text{DA}} - P_{\text{RT}} \right) - \frac{\partial C_{\text{DA}}}{\partial X} \cdot F \quad \Rightarrow
\]

Substitute Equation (2b) and rewrite:

\[
\left( \frac{\partial P_{\text{S}}}{\partial X} \right) \cdot X + \frac{\partial C_{\text{DA}}}{\partial X} \cdot F = \left( P_{\text{DA}} - P_{\text{RT}} \right) \quad \Rightarrow
\]

If \( X^\gamma > X_{\text{max}} \), then \( \left( P_{\text{DA}} - P_{\text{RT}} \right) > 0 \) \( \Rightarrow \)

\[
\frac{\partial P_{\text{S}}}{\partial X} \cdot X + \frac{\partial C_{\text{DA}}}{\partial X} \cdot F > 0 \quad \Rightarrow
\]

\[
- \frac{\partial P_{\text{S}}}{\partial C_{\text{DA}}} < \frac{F}{X} \quad \Rightarrow
\]

Therefore, because \( - \frac{\partial P_{\text{S}}}{\partial C_{\text{DA}}} \geq 1 \),

\[
\frac{F}{X} > 1 \quad \Rightarrow \quad F > X.
\]

Thus, the manipulator must own a larger FTR position (of “\( F \)” megawatts) than it places in virtual bids (of “\( X \)” megawatts) to profitably execute the manipulation such that the gains in the FTR exceed the losses in the virtual bids. If the change in the congestion price \( C_{\text{DA}} \) is less than the change in the spread \( P_{\text{S}} \), a larger FTR position is needed to give the manipulator sufficient financial leverage such that its gains from the enhanced FTR position exceed its losses accrued from the virtual trades.

\footnote{This would occur if either \( \frac{\partial C_{\text{DA}}}{\partial X} \leq \frac{\partial P_{\text{DA}}}{\partial X} \) (e.g., the DECs increased losses as well as congestion such that the change in the total LMP exceeds that of the congestion component) or \( \frac{\partial P_{\text{DA}}}{\partial X} \leq \frac{\partial P_{\text{S}}}{\partial X} \) (i.e., the DECs lowered the real-time price such that the change in the day-ahead/real-time spread exceeds the change in the day-ahead price).}

The exploitation of such a leveraged FTR position is shown in Figure 5. If more than $X_{\text{max}}$ megawatts of DEC bids clear, the trader receives an increasingly negative price ($P_{S}^{c}$) such that the loss on the last virtual bid traded ($X^{*}$) equals the gain on the enhanced value of the FTR, thereby maximizing the total revenues garnered from the combined position ($TR^{\text{a}}$). The shaded region shows the losses the trader is willing to incur on its virtual bids to enhance the value of its FTR to $FTR(X^{*})$. By definition, the losses on the virtual bids result from divergence of the day-ahead and real-time prices such that the resulting day-ahead congestion is now worse than that in the real-time. This should provide other traders with the incentive to offer offsetting virtual supply bids (INCs) into the market to profit from the high real-time price. If this does not occur, the inability or unwillingness of other market participants to restore the market to $X_{\text{max}}$ over time suggests limited market liquidity or a market anomaly that makes the manipulative behavior possible and profitable.48

48 A competitive market would see a response from many other traders, such that there would theoretically be no long-term benefit in attempting to bid DECs beyond $X_{\text{max}}$. However, the trader’s ability to leverage its gains from the financial position could allow it to bid more DECs than can rationally be countered by other market participants, especially given positive transactions costs, a likely low return on the INCs used to negate the manipulator’s virtual position, and potentially high risk of losses should the manipulator periodically and unexpectedly withdraw its bids from the market. Other factors such as the presence of “uplift” or other indirect costs could also thwart a competitive response.
Table 2
Profit Maximization Using Uneconomic Virtual Bids to Enhance FTR Values

<table>
<thead>
<tr>
<th>Location on Horizontal Axis</th>
<th>Real-Time vs. Day-Ahead Price Spread (Pₛ = 40 - X)</th>
<th>Quantity of DECs Cleared (X)</th>
<th>Total Revenues of Virtuals (TR=Pₛ*X)</th>
<th>Enhancement of FTR Value from Cleared DEC MWs (FTR = 60*(40- Pₛ))</th>
<th>Total Profit from Scheme (TR+FTR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Origin (0)</td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>30</td>
<td>10</td>
<td>300</td>
<td>600</td>
<td>900</td>
<td></td>
</tr>
<tr>
<td>Max Profit Virtuals (X*)</td>
<td>20</td>
<td>20</td>
<td>400</td>
<td>1,200</td>
<td>1,600</td>
</tr>
<tr>
<td>10</td>
<td>30</td>
<td>300</td>
<td>1,800</td>
<td>2,100</td>
<td></td>
</tr>
<tr>
<td>Convergence (X_max)</td>
<td>0</td>
<td>40</td>
<td>0</td>
<td>2,400</td>
<td></td>
</tr>
<tr>
<td>Maximum Revenues (X*)</td>
<td>-10</td>
<td>50</td>
<td>-500</td>
<td>3,000</td>
<td>2,500</td>
</tr>
<tr>
<td>-20</td>
<td>60</td>
<td>-1,200</td>
<td>3,600</td>
<td>2,400</td>
<td></td>
</tr>
<tr>
<td>-30</td>
<td>70</td>
<td>-2,100</td>
<td>4,200</td>
<td>2,100</td>
<td></td>
</tr>
<tr>
<td>-40</td>
<td>80</td>
<td>-3,200</td>
<td>4,800</td>
<td>1,600</td>
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</tr>
<tr>
<td>-50</td>
<td>90</td>
<td>-4,500</td>
<td>5,400</td>
<td>900</td>
<td></td>
</tr>
<tr>
<td>TR Intercept (X_max + X_FTR)</td>
<td>-60</td>
<td>100</td>
<td>-6,000</td>
<td>6,000</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2 exemplifies the uneconomic trading that triggers the manipulation. In addition to the assumptions made in Table 1, assume that the trader holds a 60 MW FTR position that sinks at the node where the virtual load bids clear, that the change in the day-ahead price at the sink is attributable solely to the change in congestion prices, and that the clearing of virtual bids affects neither real-time prices nor the day-ahead congestion price at the FTR’s source.49 Beyond X*, every dollar by which the day-ahead price increases will increase the profits on the FTR position but will simultaneously reduce the profitability of the virtual trades. Table 2 shows the results for DECs bid and cleared in ten MW increments. The trader now maximizes its revenues by bidding 50 MW of DECs into the market, causing the spread to diverge such that the day-ahead price exceeds the real-time price by $10/MW. This may result in the over-commitment of generation resources in the day-ahead market at this location. Compared to the 20 MW of DECs the trader would bid were it seeking to maximize the revenues from its virtuals on a stand-alone basis, the trader gives up $400 – (-$500) = $900 (an opportunity cost loss measured relative to its profit maximizing virtual trades) to gain $3,000 - $1,200 = $1,800 on its FTR. But even relative to the 40 MW of DECs needed for market convergence, the trader purposely loses $500 on its virtuals (a loss measured by its accounting cost) to create a $600 gain on its FTR. Thus, from either an opportunity cost or accounting perspective, this behavior is consistent with a market manipulation predicated on uneconomic virtual trading.

Virtual/FTR Manipulations Fit within a Generalized Framework

In other papers,50 we identified a generalized framework for the analysis of price-based market manipulation. The construct describes a manipulation as consisting of three components:

- **The Trigger**: The price-making trades strategically used by a trader to cause a directional movement in a price;
- **The Target**: The price-taking positions held by the trader that stand to benefit from the directional price movement caused by the trigger; and

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49 If the real-time price is not affected by the placement of DECs, the closure of the spread is due entirely to an increase in the day-ahead price at the sink, which is attributable solely to increased congestion costs. This simplifies the calculation of the enhancement to the FTR’s value shown in Table 2, for the change in the day-ahead price must then equal the pre-DEC spread ($40) less the spread that results after the trader’s DECs clear (Pₛ). See the discussion of convergence supra, note 29.

50 See Ledgerwood and Carpenter, * supra* note 24; and Ledgerwood and Harris, * supra* note 47.
• **The Nexus:** The linkage between the trigger and target, usually the price that is directly manipulated or other prices formed therefrom.

This framework is helpful in the analysis of different types of market behavior that can cause a directional price movement and thus, potentially, serve as a manipulation’s trigger. Behaviors that trigger market manipulation include the exercise of market power, the use of outright fraud, and the intentional execution of uneconomic trades. The use of virtual bids described above clearly falls in the latter of these three categories, as a trader’s strategy to bid excessive loss-making DECs is designed to raise the day-ahead congestion component of the LMP to benefit the trader’s FTR positions and thus trigger the manipulation. The day-ahead congestion price then serves as the manipulation’s nexus to benefit the value of the trader’s targeted FTR position. The use of virtual bids to affect the value of FTRs is thus a specific example of a more general framework suited to the broader description and analysis of manipulative behavior.51

**Conditions that Improve the Likelihood of a Successful Manipulation**

The decision to intentionally trigger a manipulation through uneconomic trading is based on a cost-benefit analysis, where the cost of expected losses in the trigger is weighed against the benefit expected from the manipulation target. As Equation (5d) shows, an increase in the size of the FTR target improves the likelihood of the manipulation’s success because the benefit derived from movement in the nexus increases as each successive DEC bid clears. Likewise, Equation (4a) shows the manipulation becomes more likely to succeed as the cost of the trigger (i.e., the negative spread between the real-time and day-ahead prices) becomes cheaper (ceteris paribus). An interesting aspect of manipulations based on uneconomic trading is the fact that marginal gains in the target are inextricably and negatively correlated with marginal losses in the trigger, as both tie to the overall scope of the uneconomic behavior with increasingly diminishing returns. The elasticity of demand and supply is therefore critical to successful manipulations, as the gain (tied to the day-ahead congestion price) and the loss (the negative spread between the real-time and day-ahead prices) increase as both demand and supply grow more inelastic. This last point resonates well with the oft-cited importance of market liquidity to the prevention of market manipulation, because lack of liquidity for bids or offers is respectively symptomatic of inelastic demand or supply.

Energy markets are particularly susceptible to market manipulation due to frequent or episodic periods of inelasticity of demand and supply during price formation and the ability of market participants to build leverage in physical and financial positions that tie to those prices. This is especially true of electricity markets, wherein lack of storage mandates that supply must be prepared in advance to meet an expected (but highly variable) demand and the quantity of the good produced must be constantly balanced with load given a litany of economic and physical constraints. These market conditions favor acts designed to trigger directional price movements, either through traditional market power used for economic withholding or through concentrated uneconomic trading designed to distort the market. Virtual bidding provides a mechanism to thwart manipulative activity by adding liquidity to the market and thus incenting convergence between the day-ahead and real-time markets. Unfortunately, virtual trades can also provide a cheap and effective vehicle for triggering a manipulation by financially-leveraged market participants, particularly at locations and during periods with limited market liquidity. It is this tension between efficiency gains and concerns of compliance and enforcement which our model is designed to reconcile, as we discuss next.

**VI. Market Efficiency, Market Monitoring, Enforcement, and Compliance**

In this section, we first discuss the degradation of market efficiency that is caused by the placement of excessive virtual bids intended to manipulate FTR values. Because the model we present herein identifies

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51 Note that the framework can adapt to explain manipulative behavior that involves a nexus other than a price. For example, in predatory pricing cases, by a multi-product market participant can recoup losses in one product segment through the sales of other items brought about through increased foot traffic. See Shaun D. Ledgerwood and Wesley Heath, “Rummaging through the Bottom of Pandora’s Box: Funding Predatory Pricing through Contemporaneous Recoupment,” 6 *Virginia Law and Business Review* 509 (April 2012).
uneconomic virtual trades as potential manipulation triggers, we next discuss ways to differentiate intentional uneconomic virtual trading designed to trigger a manipulation from legitimate virtual trading that just happens to lose money. RTOs and their Independent Market Monitors (IMMs) already use different mechanisms to screen for suspicious virtual transactions as part of their market oversight responsibilities, but these may be (or may appear to be) ad hoc absent a justification for why such trades could be suspicious in the first place. The model we propose provides the logical foundation for such screens and thus defines a consistent and logically cohesive enforcement model for evaluating uneconomic trading generally and virtual trading specifically. Consistency and transparency of enforcement will clarify the behavior that is and is not considered manipulative, thereby identifying trading “safe harbors” to simplify the compliance requirements expected of traders and reduce the uncertainty and costs of market participation. This will improve market liquidity, increase the elasticities of supply and demand, and thus reduce the likelihood of successful manipulations.

The Impact of Uneconomic Virtual Trades on Market Efficiency

The intentional placement of uneconomic virtual bids or offers introduces inefficiency into the RTO market. By purposely causing the day-ahead and real-time prices to diverge (thus creating a loss on the virtual trade), the manipulator causes the RTO to incur additional costs due to the sub-optimal generation commitment and dispatch that results from erroneous pricing between the day-ahead and real-time markets at the manipulated node(s) and across other nodes that are affected. This cost must ultimately pass to the wholesale power customers, who will pay uplift charges for resources scheduled but not used or higher energy and ancillary services charges for the dispatch of resources not scheduled in the day-ahead market.

In addition to this market inefficiency, the manipulation causes a redistribution of wealth to the detriment of three groups. First, physical and financial market participants that are on the same side of the day-ahead and real-time markets as the manipulator’s trades are harmed. For example, in the manipulation shown in Figure 5, buyers in the day-ahead market will pay an uneconomically high price for power while sellers in the RTM may receive an artificially low price due to the over-commitment of generation in the day-ahead market. Second, the counterparties to the manipulator’s FTR position(s) are harmed, as are other market participants with equivalent physical or financial positional risk. Third, to the extent the manipulated prices are relied upon for future resource scheduling and planning purposes, inefficiency and wealth transfers could continue into periods extending beyond the manipulation’s scope.

The oft-stated solution to abate such efficiency concerns is to maximize the liquidity in the market such that manipulative behavior is muted or negated through robust trading, a feature which virtual trading generally provides. We agree with this solution but for one caveat: that greater volume does not necessarily equate with better liquidity. Traders who can establish financially leveraged price-taking positions can bring liquidity to the market for legitimate hedging and speculation, but also can opportunistically use such positions as the target of a manipulation. Virtual bids then provide a mechanism through which relatively small losses on uneconomic trades can trigger large gains from FTRs or other equivalent positions. Trying to prevent such behavior using position limits or other restrictive regulation is undesirable as it arbitrarily reduces legitimate trading in the market. A better way to enhance market liquidity is to recognize the characteristics that separate legitimate and manipulative trading.

The Characteristics of Legitimate Versus Manipulative Virtual Trading

Based upon a casual interpretation of our presentation in Section V, the reader might assume that we are proposing to define manipulative virtual trading by the existence of losses in each hour. This is not the case. Absent an extraordinarily anomalous event, evidence that a trader lost money on one bid placed at one node in one hour will not provide meaningful evidence of manipulation, irrespective of how that trade affected the trader’s FTRs or other price-taking positions. Indeed, if the markets into which virtuals are placed are

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52 See Celebi et al., supra note 25, pp. 20-21.
53 Specifically, a virtual bid or offer placed in size near the physical limits of the node and at a price sufficiently uneconomic so as to guarantee clearing could reasonably give rise to inquiries as to the trader’s motivation.
competitive, the trader should lose money on about half of its virtual trades placed over time because the mean value of those trades should tend to zero given market convergence, the law of large numbers, and the central limit theorem. To properly define the manipulative placement of virtuals, it is therefore necessary to prove a trader frequently and consistently incurred losses on these transactions over the course of time.\textsuperscript{54} Even if anomalous losses are demonstrated, the proof of a manipulation requires further showing that the trades in question were used to benefit financially-leveraged positions through a nexus sufficiently causal to link the manipulative trigger to the targeted positions.

By way of contradiction, the characteristics of manipulative trading as defined by our proposed framework are equally useful in identifying the characteristics of legitimate trading. For example, assertions of “anomalous” losses can be refuted if the trader under scrutiny can show that the trades in question were designed to make money on a stand-alone basis relative to the trader’s opportunity cost. Indeed, if the trader can demonstrate positive or zero profit on its virtual trades, concerns as to its opportunity costs are irrelevant because the outcome enhances the efficiency of the market by converging the day-ahead and real-time prices.\textsuperscript{55} However, even if anomalous losses are shown, the trader can refute a manipulation claim by proving that its net price-taking positions exposed to the manipulated price were held in financially unleveraged quantities, for the manipulation cannot be profitable if the alleged target is sufficient only to hedge positional risk. Finally, the presence or absence of the nexus between different pricing relationships could be used to establish a defense. For example, a trader could refute an assertion that it held a financially leveraged FTR position by showing that the congestion component of the day-ahead LMP moved less than the total LMP, thus making the size of the FTR position too small to support a profitable manipulation. Likewise, a suspected financially leveraged FTR position held at one location could be proven to be only a hedge if the impact of FTR positions held at other related locations is considered.

Market Monitoring and Screening for the Manipulative Use of Virtual Bids and Offers

The potential for virtual trades to move day-ahead prices to exploit the nexus to FTRs is well known, and the IMMs regularly (though unevenly) screen for this behavior.\textsuperscript{56} Inherent to all such analyses are concerns of false positives (Type I errors) and false negatives (Type II errors), such that the screens used cannot effectively distinguish between losses from legitimate trading and those from manipulative behavior because they either falsely identify legitimate trades as manipulative or fail to identify manipulative trades. For example, setting a threshold for losses on virtual bids at a fixed $/MWh may falsely detect losses over the threshold that are incurred on legitimate trades while failing to detect smaller losses that drive manipulative ones. This may over-deter some legitimate trading and under-deter some manipulation. Layered sets of screening thresholds and multiple types of screening methodologies could partially allay these concerns by providing robustness...

\textsuperscript{54} For a loss-based manipulation to be effective, the trigger must impact the price-making mechanism such that the information conveyed is not filtered out as noise or snuffed out by the weak law of large numbers. Hellwig, p. 493. To detect such behavior thus requires the ability to screen for anomalous losses against the backdrop of the noise of the market. Because such “anomalies” will also include legitimate transactions through which informed traders gather information, a presumption of legitimacy must attach to all open market trades as a null hypothesis. The burden then falls on the party alleging the manipulation to prove that the behavior in question rejected this hypothesis and thus fell outside of the level of market “noise” associated with legitimate trading. In the context of the uneconomic placement of virtual bids or offers, this burden requires proof that the accused trader anomalously placed excessive bids or offers to cause or attempt to cause directional price movements through a pattern of trading exhibited over time. See Ledgerwood and Carpenter, \textit{supra} note 24.

\textsuperscript{55} See the discussion \textit{supra} note 44 concerning the placement of DECs that are profitable on an accounting basis but that fail to cover its opportunity cost of maximal virtual bid revenues (such that $X^* < X^\ast < X_{\max}$).

\textsuperscript{56} For example, the Midwest ISO screens for uneconomic trades “generating losses greater than $50 per MWh” but rarely finds transactions of concern, noting “Virtual losses that warrant further investigation have been rare and only one pattern of trades warranted mitigation.” 2010 State of the Market Report for the MISO Electricity Markets, pp. 37-38. By comparison, PJM employs a “Forfeiture Rule” which requires automatic forfeiture of a FTR’s profits if virtual trades are placed in a proximity that could influence their value. See \textit{PJM Open Access Transmission Tariff, Attachment M – Appendix, Part VI} at p. 1733 (February 8, 2012).
checks, though the party seeking to prove (or disprove) the manipulation must be mindful of the biases that such screens could produce.\textsuperscript{57} Given proper vetting of false positives and a screening methodology consistent with a null hypothesis of trade legitimacy, such errors can be mitigated by tailoring screens to detect specific behavior of concern for specific components of the manipulation.

\textit{The Implications of the Framework on Enforcement}

Anti-manipulation enforcement cases are challenging due to the asymmetric presumption of legitimacy that follows the trader’s decision making and the inability to observe the trader’s private information set \textit{ex ante} an allegation. For example, in response to evidence that a trader willingly lost money on virtual bids to trigger a manipulation, the trader may assert the bids were placed to hedge against possible generation outages at that node and thus served a stand-alone legitimate business purpose. To counter evidence that the trader accumulated FTRs to create a financially-leveraged net position to benefit from the trigger, the trader could point to selected sets of unobservable physical and financial positions that relate to the trigger and target, the sum (or strategically chosen partial sum) of which could negate proof of a viable manipulation target. Disagreement as to the appropriate strength of nexuses across nodes and across markets will also support the inclusion or exclusion of specific transactions to the trigger and target. The ability of an alleged manipulator to assemble a potentially limitless number of counterfactuals \textit{ex post} the specific alleged behavior therefore presents a significant advantage against which already constrained agency resources are pressed to rebut.

To preemptively counter such tactics, enforcement actions establish a pattern of losses accrued over time in conjunction with other “smoking gun” evidence to demonstrate intent to execute a manipulative scheme. The model we present provides a concrete way to explain how virtual trades, FTRs, and a broad set of other price-making and price-taking instruments can be used to manipulate power markets. Although a manipulator could theoretically offer limitless alternative counterfactual explanations as to how these transactions interrelate to defend against the allegations, pragmatism dictates that a trier of fact will accommodate only a few such alternative perspectives before deeming the defense as disingenuous.

Thus, the key to any successful proof or disproof of a manipulation claim is recognition of behavior that can and cannot be manipulative. Trading strategies that make money on a stand-alone basis relative to their opportunity cost serve a legitimate business purpose, as do financial positions accumulated in size only to serve as a hedge. Conversely, the repeated accumulation of anomalous losses on uneconomic price-making trades is suspicious and could be manipulative if a sufficient nexus is established to leveraged price-taking positions. Given the difficulties in detection and enforcement, it will undoubtedly be true that there will be a threshold under which potentially manipulative behavior will not be investigated.\textsuperscript{58} However, by identifying behavior that is and is not manipulative, the framework can help narrow the contested issues that arise in anti-manipulation enforcement actions to the benefit of the agencies and accused alike.

\textit{Simplified Compliance in Wholesale Electricity Markets}

The historical precedent set by previous anti-manipulation cases tried in the U.S. declared several categories of behavior as manipulative without providing a common economic logic across the cases tried. This example-driven approach provides little guidance as to the behavior that regulators see as manipulative, leading traders to either avoid legitimate trades to prevent suspicion under uncertain enforcement standards or to pursue potentially manipulative behavior given the historical difficulties agencies have had in successfully bringing

\textsuperscript{57} This is not meant to disparage the usefulness of such screens, as more transparent tests for supporting or defending manipulation claims are desirable and could provide better standards of proof upon which a trier of fact could rely for evaluating alleged manipulative behavior. By comparison, reliance on tailored econometric analyses often provide “black-box” results to evaluate manipulative behavior, placing the trier of fact in the uncomfortable position of refereeing the “battle of the experts” with little straightforward evidence of manipulative behavior.

\textsuperscript{58} Note that the example provided in Figure 5 recognizes that this is the case, for there is a range of trading activity shown (between $X^*$ and $X_{max}$) wherein the behavior could be classified as manipulative but where detection and proof thereof is impossible because $TR^*$ is unobservable.
enforcement cases. The framework we propose can improve market compliance by clarifying what trading activity does and does not constitute market manipulation and can inform the treatment of other types of behavior that might be used to manipulate wholesale electricity markets. Such clarity will benefit market participants by reducing the uncertainty of questionable trading and facilitating the disproof of erroneous allegations of manipulative behavior. This is especially important given the possibility of dual regulation by the FERC and CFTC, because the coordination of enforcement regimes under a uniform framework would bring certainty to market participants as to the behavior that will and will not be prohibited, thereby simplifying compliance efforts to the benefit of market liquidity.

VII. Conclusion

The framework we propose herein is helpful to the analysis required to prove or disprove market manipulations using virtual trades because it identifies the components and market characteristics that are needed to implement a successful manipulation. While the proof of a trader’s anomalous virtual trading losses may identify a possible manipulation trigger, such proof is irrelevant absent demonstration of financially-leveraged positions that could serve as the manipulation’s target and of a causal nexus between the suspected trigger and the targeted positions. Possible targets include observable positions such as FTRs, but may also include more opaque positions such as derivatives or physical assets that are valued based on day-ahead or real-time prices. Because the complexities of nodal power markets dictate that actions directed at one node will generally affect many other nodes with varying effect, the identification of a net position across potential targets should consider all positions for which a strong nexus exists. This is especially relevant at times and locations where demand or supply is highly inelastic.

Because the CFTC and FERC share equivalent anti-manipulation rules post Dodd-Frank, the economic logic of the framework could provide a consistent methodology for both agencies to evaluate uneconomic behavior in the wholesale power markets from a common perspective, such that concerns of overlapping or shifting oversight and enforcement standards are negated. Jurisdictional complementarities could assist the development of joint screens, testing for the accumulation of price-taking positions in aggregate size sufficient provide the financial leverage to act as the target for a manipulation. The sharing of institutional knowledge as to the timing of and processes under which related physical and financial instruments clear will also be valuable to better understanding the nexuses by which market manipulation could occur. Coordination of enforcement would preserve scarce regulatory resources and would provide greater certainty as to differentiating legitimate and manipulative behavior to the benefit of all market participants.

Concerns that explaining the workings of a loss-based manipulation as we have herein will lead to the deployment of ever more aggressive screening methodologies by overzealous regulators are ill-founded. The concepts suggested herein do not focus on isolated incidents of unlucky or risk-averse trading, but on uneconomic behavior that persists with such repetition or magnitude that a rational trader would avoid the loss but for the existence of some benefiting physical or financial target. Clarification of the behavior that is and, perhaps more importantly, that is not manipulative will help improve screens for market manipulation, reduce the likelihood of false positives and false negatives and, importantly, reduce the cost of future compliance and enforcement efforts through the establishment of trading safe harbors and a better understanding and communication of the behavior prohibited.

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59 FERC Chairman Jon Wellinghoff has disputed such concerns, noting “I think anybody who reads the Constellation case can get hopefully a very clear signal of what is manipulation… You can't lose a whole bunch of money in one market . . . to in essence gain substantial amounts of money.” Esther Whieldon and Kate Winston, “Consistency on Identifying Manipulation Urged,” Platts MW Daily (April 26, 2012).