Competition and efficiency in Alberta's electricity futures market[1]

Extended Abstract

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Overview

Alberta has operated an energy-only electricity market for more than two decades. It has sought to incentivize investment by explicitly permitting non-cooperative or unilateral exercise of market power to provide for fixed cost recovery and address the 'missing money' problem. Many other jurisdictions have mandated a capacity market to address this issue.[4] Such market designs have become increasingly complex administratively and some jurisdictions and regulators (including FERC) are reconsidering the wisdom of relying heavily on the capacity market construct. On the other hand, recent events in Texas may lead to increased scrutiny of energy-only market design. A thorough understanding of the Alberta market design, industry structure, and the efficacy of relatively light-handed regulation, is invaluable for informing the evolution of electricity markets worldwide, particularly as energy systems decarbonize.

An important component of the Alberta market design is a vigorous futures market in which buyers can protect themselves against high prices and sellers can secure revenue streams. In the absence of a capacity market, futures markets comprise an important mechanism for signalling and supporting investment, thereby promoting resource adequacy and dynamic efficiency. They also contribute to competitive price formation through the reduction in incentives for the exercise of market power in the spot market (see, e.g., Wolak (2019)).

This paper considers competition, efficiency, and liquidity in Alberta's electricity futures market. Our analyses are organized along two broad strands. The first investigates the relationship between futures and spot prices; the second models the evolution of futures prices as the date of delivery approaches. In both cases, the inability to store electricity in a cost-effective manner is fundamental to the economics of these markets. We also examine factors which have affected liquidity in Alberta futures markets. Our data consist of approximately 12,000 observations on future contract prices over the period April 2008 to March 2021. To our knowledge, there are no detailed econometric assessments of the Alberta futures market.

There is a substantial literature on the relationship between futures and spot prices. We begin with the usual unbiasedness hypothesis and assess whether futures prices provide an

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[1] This paper is part of a broad research program which surveys and analyses the Alberta electricity market experience over the last two decades, as well as its relevance to electricity market design and energy transitions worldwide.

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[4] Alberta undertook a multi-year process, the purpose of which was to develop and implement a capacity market. The idea was ultimately discarded, and an energy-only market structure was retained.

unbiased forecast of realized spot prices. We find occasionally large differences between futures and spot prices (the futures premium) in individual months but limited evidence of systematic variation over time. We then augment our model to account for information that was revealed after futures prices have been set, but before the spot market clears. We find that a meaningful portion of the futures premium can be explained by differences between expectations and realizations of key variables that affect market conditions, including generation and transmission outages, natural gas prices, production by intermittent generators, and import capacity.

To analyze the evolution of futures prices as a function of time to delivery, we construct models for the 156 distinct monthly futures contracts that cover our study period. Due to the non-storability of electricity, contracts should arguably be independent of current market influences. Nevertheless, we find statistical evidence of common responses of futures prices to current spot price levels and volatility, even months in advance.

We find that futures prices are influenced by macroeconomic and policy shocks, including changes in carbon prices; they efficiently anticipate the effects of discrete policy changes following their announcement, and in advance of implementation; and that the predictive power of futures prices initially deteriorates the more distant the delivery date (as expected) but eventually improves and stabilizes as the time to delivery continues to increase (not as expected).

The Alberta electricity market

Alberta is rich in hydrocarbons. Approximately 90% of its electricity is generated using coal and natural gas. The spot market is organized as a centrally-dispatched gross power pool: all physical power, except for that consumed on the site where it is generated (i.e., behind-the-meter), must be exchanged through the pool which is operated by the Alberta Electric System Operator, an independent entity. The marginal dispatched generator in each minute sets the market price, known as the System Marginal Price (SMP). The SMP prevails until it changes. The pool price, which is used for settlement, is the time-weighted average of the SMPs in each clock hour. There are no locational prices in Alberta and so this pool price is the same for all loads and generators, including importers and exporters. There are no physical transmission rights.

Alberta has an “energy-only” market. Aside from a relatively small market for operating reserves, generators must recover all of their costs from the power pool, including the fixed costs of generation capital. Alberta does not make use of administrative scarcity pricing,[5] (usually associated with an operating reserve demand curve) where prices are administratively set at relatively high levels intended to approximate the value of lost load when the quantity of operating reserves is relatively low. Alberta has a relatively low offer price cap (in effect, the market price cap) of C$999.99/MWh.

As a result of these market design features, there is an expectation that oligopolistic offer strategies which can incorporate the exercise of market power, will increase the pool price above marginal cost in a relatively small fraction of hours—usually 5% to 15% of hours. To be clear, supply need not be physically exhausted for suppliers to exercise non-cooperative market power, see e.g., MSA (2020). While electricity spot prices are notoriously volatile in most

[5] In Texas, ERCOT has relied on scarcity pricing, but this is under revision in view of the extraordinarily high prices that were experienced during the winter storm in February 2021.

jurisdictions, the exercise of market power can lead to increased volatility. In this respect, Alberta's electricity market operates more like a usual commodity market (e.g., oil or natural gas) than like electricity markets where institutional design, rather than market forces, keeps price close to marginal cost (e.g., New York or California).

The financial futures market

In light of these market features, both suppliers and consumers have incentives to hedge their spot market exposure. These incentives are the ultimate sources of supply and demand in the futures market, which is purely financial in nature.

As in other futures markets, a variety of products have been developed that serve the needs of market participants. The two most important characteristics of any futures contract are its term and shape. The term is the length of the delivery period that is covered by the contract. The most common terms are calendar months, quarters, and years. The shape defines the specific hours in the delivery period that are subject to delivery. The two most common shapes are a "flat" which includes all hours of the term, and "extended on-peak" which covers the period from 7 a.m. to 11 p.m. each day. Contracts with other terms and shapes exist but are not traded as widely.

Unlike the spot market where all trades must take place through the power pool, futures contracts are traded bilaterally on and off exchanges. Trading can begin a few years in advance and continue until delivery. Liquidity varies over time and across contracts with volumes typically increasing in the months approaching the delivery date.

Dataset

We have assembled a uniquely rich dataset on 156 monthly flat contracts with delivery periods that correspond to the 156 months from April 2008 to March 2021. Given that liquidity increases in the year preceding delivery, most of our analysis is of trades during this period. [NTD: Consider extending window to include sparser trade periods and/or non-flat products.] Each of these contracts was observed to trade on an average of 75 distinct days in advance of delivery. As a result, our dataset includes not only the last futures price before the beginning of delivery, but also the evolution of the price for each contract. In aggregate terms, the contracts that form the basis of this dataset resulted in the financial exchange of approximately 320 TWh of electricity worth C$18.3 billion.

In addition we have collected data on certain key explanatory variables that may explain (i) the difference between futures and realized spot prices and (ii) the evolution of futures prices. These include:

- long-run average and realized generator outages, transmission outages, wind and solar production, and weather conditions;
- the evolution, as the delivery month approaches, of planned generator outages, transmission outages, and natural gas futures prices; and
- a variety of policy variables, including the development and implementation of carbon pricing, and data on the Balancing Pool.[6]

[6] A belief in the late 1990s that the wholesale market was too concentrated to be competitive led to the implementation of a scheme of virtual divestitures called Power Purchase Arrangements (PPA) whereby

Methodology

Futures prices as predictors of spot prices

Observed spot prices

Economic theory posits an equilibrium relationship between futures and expected spot prices (e.g., Bessembinder and Lemmon (2002)). Discounting aside (non-storability means that there are no relevant carrying costs), the presence of risk aversion may mean that futures prices will not equal expected spot prices. More importantly, from an empirical perspective, expected spot prices are unobserved. Notwithstanding this, there is a substantial literature (e.g., Redl and Bunn (2013), Bevin-McCrimmon et al. (2020)) that compares futures prices to subsequently observed spot prices.

We consider various tests of market efficiency, the simplest being of the ‘unbiasedness hypothesis’. The underlying idea is to assess whether the futures price at time *t* for delivery period *T* provides an unbiased forecast of the spot price in period *T*:

$$S_T = \beta_0 + \beta_1 F_{t,T} + \varepsilon_t. \qquad (1)$$

We test the unbiasedness hypothesis for various intervals in advance of delivery, i.e., for various values of *T-t*. Since the information about the delivery period improves as the delivery approaches, we expect that, all else equal, the predictive accuracy of futures should improve as the time to delivery declines.

Expected spot prices

Embedded within futures prices are expectations of spot market conditions. We therefore augment equation (1) with variables that reflect changes in forecasts or expectations. These include information about the realizations of random variables such as weather, supply and transmission outages, and natural gas prices (a key input cost). To the extent that realizations of these variables differ from forecasts, the futures price would have inaccurately forecast the observed spot price. Put another way, the futures price is a forecast of expected conditions not realized conditions. The augmented model takes the form:

$$S_T = \beta_0 + \beta_1 F_{t,T} + X_t' \boldsymbol{\theta} + \varepsilon_t \qquad (2)$$

We expect that variables that are more predictable are more likely to be statistically significant than variables that cannot be accurately forecast. In particular, natural gas is a storable commodity (and is therefore subject to intertemporal price arbitrage) that trades in a highly liquid market of its own. To the extent that natural gas prices in the delivery month are say higher than forecast at the time the electricity futures traded, then subsequent spot prices will exceed futures prices. The deviation of observed natural gas prices from forecasts may explain some of the variation of the observed spot price that is not explained by the futures prices.

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physical ownership of legacy generation capacity was unaffected, but economic control was transferred to different participants. The government of Alberta created a market participant called the Balancing Pool to act as an intermediary between the participants in this scheme, as well as assigning to it a back-stop role in the event that a participant could not take initially economic control or decided later to exit a PPA.

In effect, augmenting the model with this additional information changes the interpretation of the results. Mathematically, it can be rewritten as:

$$S_T - X_t'\boldsymbol{\theta} = \beta_0 + \beta_1 F_{t,T} + \varepsilon_t \qquad (2a)$$

In this reformulation, the variable $S_T - X_t'\boldsymbol{\theta}$ is the observed spot price adjusted for new information that arrived after the futures traded. In effect, equation (2a) provides a way to model the expected spot price. To the extent that any of this additional information is statistically significant, then there is evidence that the expected spot price differed from the observed spot price in a non-random manner.

Preliminary findings on spot prices

Our preliminary findings indicate that (i) futures prices very near to delivery provide an unbiased forecast of spot prices, (ii) this holds even in the non-augmented model, suggesting that most relevant information about the delivery period is known just before it begins, (iii) the forecast becomes more precise as the time to delivery decreases, (iv) certain information that is realized after futures prices have been determined, is statistically significant in explaining differences between futures prices and spot prices in the delivery period, and (v) we can distinguish the expected spot price from the observed spot price.

There are also policy implications arising out of these findings, one of which is highlighted here. Alberta has a competitive retail electricity market.[7] Small retail customers (i.e., households) that do not want to choose a competitive retailer are entitled to a regulated rate. That rate is effectively an index of futures prices (for the delivery period) in the 120-day period prior to the beginning of the delivery period. The 120-day period is a policy variable and the performance of futures prices—and their relationship to spot prices—impacts its selection. Our analysis can contribute to discussions of the trade-off between smoothing volatility impacts on customers and ensuring spot price trends are reflected in retail rates in a timely fashion.

Determinants of Futures (and Spot) Prices

Futures prices are affected by expectations of conditions during the delivery month. They may also be affected by current market conditions to the extent that these may inform future expectations. Our basic model is:

$$\begin{aligned}\log\left(F_{t,T}\right) = \alpha_0 + MO_t\delta + \beta_1 lavg_t + \beta_2 \mathrm{lvar}_t \\ + \beta_3 lfpng_{t,T} + \beta_4 lfoutage_{t,T} + \beta_5 lfatc_{t,T} + \beta_6 bp_T + \varepsilon_t\end{aligned} \qquad (3)$$

$$\begin{aligned}\log\left(F_{t,T}\right) = \alpha_0 + MO_t\delta + f_1\left(lavg_t\right) + f_2\left(\mathrm{lvar}_t\right) \\ + g_1\left(lfpng_{t,T}\right) + g_2\left(lfoutage_{t,T}\right) + g_3\left(lfatc_{t,T}\right) + g_4\left(bp_T\right) + \varepsilon_t\end{aligned} \qquad (3a)$$

where

- MO_t is a vector of monthly dummies with corresponding coefficient vector δ ;

[7] Competition is mostly in the form of prices. Physical service is provided by local distribution facility operators and does not depend on the retailer.

- $lavg$ and lvar are the logs of the mean and variance of current 30-day spot prices S_t;
- $lfpng_{t,T}, lfoutage_{t,T}, lfatc_{t,T}$ are logs of natural gas futures, forecast outages and forecast transfer capacity;
- bp_T is the actual Balancing Pool share in the delivery month; and
- the f_j and g_k are smooth nonparametric functions which are intended to capture nonlinearities or threshold effects that may appear in the data.

Equation (3) is our base parametric specification and (3a) is a more flexible variant. We will estimate other variations of (3), including panel data versions which will permit modeling of the effects of 'time to delivery' on futures prices for the 156 contracts.

Preliminary findings on futures prices

Our preliminary findings provide robust statistical evidence that futures prices are affected by levels and variation in current spot prices. (Higher order moments are insignificant.) While this would be unsurprising for a storable commodity, it is somewhat surprising for electricity. This is because non-storability has the effect of rendering each contract, corresponding to a distinct delivery period, to be a separate product with limited or no substitutability. It is an open question why, in the presence of non-storability, this relationship exists. For example, it is not clear why an increase in spot prices in say September should raise futures prices for December.

Brown and Olmstead (2017) documented the exercise of market power in the Alberta electricity market. This is characterised by prices rising above marginal cost in 5% to 15% of hours. While such outcomes are consistent with competition in the presence of economies of scale (and no capacity payments), our finding here that spot price changes affect future prices means that market participant conduct that is intended to raise current spot prices may also raise futures prices as a reasonably foreseeable consequence. While cost non-convexities such as start-up costs have long been understood to be a critical part of suppliers' profit maximization problems (e.g., Mansur (2007) and (2008)), thereby linking offer strategies and market outcomes across different delivery hours in the short-term (periods up to a couple of days in the case of start-up costs), the linkage that we have identified is important for understanding how market participants profit from their conduct. Specifically, a supplier with market power may raise its offer prices above marginal cost both to obtain a higher spot price for its production in the short term (say in the day the offers are made) but also to raise futures prices for delivery periods that they can sell into. In other words, the profit maximization problem that suppliers solve — and that observers and regulators assume they are solving — is more complex than each hour being independent of the others. It is in this sense that our results contribute to the literature on strategic commitment and signalling.

Further, these findings inform the research on how futures prices, and therefore expected spot prices, should be modelled by identifying a critical role for spot prices from earlier periods. Among the open questions is whether this means that market prices are, to an extent, fulfilled prophesies.

Conclusions

The energy-only design makes the Alberta electricity market particularly useful for informing discussion of the evolution of electricity markets. Due to the absence of a capacity market, the futures market plays an important role in reducing investor risk. Further, compared to most electricity markets, the offer strategies of Alberta market participants are subject to relatively little regulation, with greater reliance on, and confidence in the role of competition. This heightens the importance of futures markets in both reducing and modulating the exercise of market power and in providing large consumers and retailers with options to hedge their cost risk.

The findings reported thus far, namely that (i) futures prices provide an unbiased forecast of spot prices, (ii) a substantial portion of the resulting futures premium can be explained by the information that is obtained after the futures price is set but before spot prices are determined, and (iii) that futures prices appear to efficiently reflect changes in available information, lend support to a conclusion that the Alberta futures market is competitive and makes efficient use of information. As electricity markets transition to greater use of intermittent, non-emitting resources, these characteristics are highly desirable in markets where necessary investments are made by competitive firms without explicit contracts or directions from government or government entities.

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Bio: Adonis Yatchew's research focuses on energy, regulation and econometrics. Since completing his Ph.D. at Harvard University, he has taught at the University of Toronto. He serves as Editor-in-Chief of The Energy Journal. He has advised public and private sector companies on energy, regulatory and other matters for over 35 years and has provided testimony in numerous regulatory and litigation procedures. Currently he teaches undergraduate and M.A. level courses in energy economics, PhD. level courses in econometrics and 'Big Ideas' courses on energy in the School of Environment.