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Measuring the competitiveness benefits of a transmission investment policy: The case of the Alberta electricity market

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HIGHLIGHTS

- Define competitiveness benefits to consumers from transmission expansions in wholesale market.
- Compute upper and lower bounds on competitiveness benefits for Alberta market.
- Compare no-perceived congestion prices to actual prices to measure competitiveness benefits.
- Economically substantial competitiveness benefits found for sample period studied.
- To ensure adequate transmission, planning processes should account for these benefits.

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ABSTRACT

Transmission expansions can increase the extent of competition faced by wholesale electricity suppliers with the ability to exercise unilateral market power. This can cause them to submit offer curves closer to their marginal cost curves, which sets market-clearing prices closer to competitive benchmark price levels. These lower wholesale market-clearing prices are the competitiveness benefit consumers realize from the transmission expansion. This paper quantifies empirically the competitiveness benefits of a transmission expansion policy that causes strategic suppliers to expect no transmission congestion. Using hourly generation-unit level offer, output, market-clearing price and congestion data from the Alberta wholesale electricity market from January 1, 2009 to July 31, 2013, an upper and lower bound on the hourly consumer competitiveness benefits of this transmission policy is computed. Both of these competitiveness benefits measures are economically significant, which argues for including them in transmission planning processes for wholesale electricity markets to ensure that all transmission expansions with positive net benefits to electricity consumers are undertaken.

1. Introduction

The transition from a price-regulated, vertically-integrated monopoly regime to the wholesale market regime in the electricity supply industry has dramatically altered the role of the transmission network. Under the vertically-integrated monopoly regime, the electric utility had a requirement to serve all demand in its service territory at the regulated price. This mandate provided a strong incentive for the utility to operate its existing generation units in a least-cost manner given the configuration of its transmission network and the geographic location of the daily electricity demand served, and to make investments in additional transmission capacity when this was the least-cost approach to supply load growth in a given geographic area.

In contrast, under the wholesale market regime the owner of the transmission network is financially independent of any generation unit owner and receives a regulated revenue stream that is independent of the level of congestion in the transmission network. An owner of multiple generation units selling into a wholesale market can find it expected profit-maximizing to exploit the configuration of the transmission network to cause transmission congestion and shrink the size of the geographic market over which its units face competition in order to increase the revenues it receives from participating in the wholesale

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market.[1]

For these two reasons, the transmission network takes on a new role in the wholesale market regime as facilitator of competition. Therefore, the configuration of the transmission network determines the extent of competition that each supplier faces for a given geographic distribution of electricity demands. Transmission expansions can increase the number of hours of the year that a supplier faces sufficient competition to cause it to submit offer curves close to its marginal cost curve and thereby yield lower market-clearing prices.

The competitiveness consumer benefit of a transmission expansion is the reduction in wholesale revenues – the amount consumers pay for wholesale electricity – as a result of the transmission expansion causing more competitive offer behavior by wholesale suppliers. This occurs because the upgrade allows more generation unit owners to compete to supply electricity at potentially every location in transmission network.[2] In the former vertically-integrated monopoly regime, the standard measure of the economic benefits of a transmission expansion was the reduction in the total cost of the vertically-integrated firm serving system-wide demand as a result of the upgrade. There are also likely to be production cost reductions associated with reducing the incidence of transmission congestion because lower cost generation units can operate more frequently. Because the transmission network in the wholesale market regime is financially separate from the generation segment of the industry and generation unit owners can take actions to profit from the configuration of the transmission network at the expense of electricity consumers, if the annual consumer benefits associated with an upgrade are greater than the annual fixed and variable cost of the expansion, consumers collectively should be willing to pay for this upgrade.[3]

This paper presents an empirical approach that quantifies the magnitude of the competitiveness benefits from a hypothetical transmission expansion for a wholesale electricity market. Upper and lower bound estimates are computed for the change in hourly market prices and wholesale energy costs to consumers in the Alberta Wholesale Electricity Market (AWEM) that result from increasing the extent of competition that the five largest suppliers in the market face because of an expected reduction in the frequency and duration of transmission constraints. These counterfactual market outcomes also yield upper and lower bounds on the production cost saving associated with reducing the frequency and duration of transmission congestion. Both counterfactuals yield economically significant competitiveness benefits to electricity consumers from a transmission policy that causes the five largest suppliers to perceive a low frequency and duration of transmission constraints. These results imply that failing to account for this source of consumer benefits in the transmission expansion planning process for regions with formal wholesale electricity markets can leave transmission expansions with positive net benefits to electricity consumers on the drawing board.[4]

The approach used to assess the competitiveness benefits of transmission expansions builds on the models of expected profit-maximizing offer behavior described in Wolak (2000, 2003, 2007), where suppliers submit hourly offer curves into the short-term market to maximize their expected profits from selling energy given the distribution of residual demand curves they face. As shown in Wolak (2000), this residual demand curve distribution determines the extent of competition that a supplier faces, and therefore how close the supplier's offer curve is to its marginal cost curve. Transmission expansions typically reduce the slope of the realized residual demand curves that a supplier faces because more offers from other locations in the transmission network are not prevented from competing with that supplier because of transmission constraints. These flatter residual demand curves cause an expected profit-maximizing supplier to submit an offer curve closer to its marginal cost curve. If all strategic suppliers face flatter residual demand curve realizations because of increased transmission capacity, then they will find it expected profit-maximizing to submit offer curves closer to their marginal cost curve which will yield market-clearing prices closer to competitive benchmark levels.

The major challenge associated with computing these counterfactual offer curves for each strategic supplier is quantifying how the curves will change in response to each supplier facing a flatter residual demand curve distribution because of the transmission expansions. The approach used here is based on the framework implemented by McRae and Wolak (2014) to determine how much a supplier's offer curve into the hourly short-term market changes in response to changes in the residual demand curve that it faces that hour. An econometric model relating the hourly offer price submitted by a supplier to the hourly inverse semi-elasticity of the residual demand curve (defined in McRae and Wolak, 2014) faced by that supplier is estimated for each of the five large suppliers in the AWEM using the hourly offer curves submitted by all market participants over the period January 1, 2009–July 31, 2013.[5] For each of the five of the largest suppliers, the model estimated yields an increasing relationship between the supplier's hourly offer prices and the hourly inverse semi-elasticity it faces.

This estimated relationship between the hourly offer price and hourly inverse semi-elasticity for each market participant is used to compute a counterfactual offer curve for each supplier that is the result of the perceived increased competition that the strategic supplier would face as a result of increased transmission capacity. This is accomplished through the following process. First, a no-congestion residual demand curve is computed for each hour for each supplier using the offer curves actually submitted by all

[1] Borenstein et al. (2000) use a two-node model of quantity-setting competition between two suppliers separated by finite-capacity transmission line serving price-responsive demands at both nodes to show that limited transmission capacity between the two locations gives each firm an additional incentive to restrict its output in order to congest the transmission line and reduce the competition it faces in its local market in order to raise the price it receives for its output. The authors also demonstrate that relatively small investments in transmission capacity can yield significant increases in the competitiveness of realized market outcomes. Arellano and Serra (2008) extend this result to the case of a cost-based short-term market similar to the ones that exist in a number of Latin American countries. The amount of transmission capacity between the two regions impacts the mix of high fixed-cost and low variable cost base load capacity and low fixed-cost and high variable cost peaking capacity suppliers choose, with additional transmission capacity causing suppliers at both locations to choose a capacity mix closer to the socially efficient level.

[2] This change in supplier behavior pre- and post-hypothetical transmission upgrade should account any market power mitigation mechanisms that impact supplier behavior in the short-term market.

[3] Although competitiveness benefits are primarily a transfer from electricity generation unit owners to electricity consumers, to the extent wholesale prices are lower because of the transmission expansion, retail electricity demand may be higher if the lower wholesale prices are passed on into lower retail prices. In addition, there may be system-wide operating cost savings from the transmission upgrade because more lower marginal cost units are able to serve demand. Consequently, there are also potential consumer surplus and producer surplus gains as a result of the upgrade.

[4] Awad et al. (2010) estimate the economic benefits associated with the Palo Verde-Devers Number 2 transmission line expansion in Southern California and find that the competitiveness benefits associated with this upgrade are a significant source of the economic benefits to electricity consumers and the upgrade would be more likely to fail the economic benefits versus cost test without them.

[5] The hourly generation unit-level offer curves submitted by each of the five largest suppliers in the market are used to compute each supplier's hourly offer price and the hourly market demand and aggregate offer curves of all other market participants are used to construct the hourly residual demand curve facing each large supplier.

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