**Introduction**

- Energy beet is a potential feedstock candidate to qualify for advanced biofuels and able to meet the Renewable Fuel Standard (RFS2) mandate.
- Efforts are underway to develop energy beet ethanol refineries in North Dakota and California.
- We evaluated optimal investment decision rules for an energy beet ethanol firm to simultaneously exercise the option to invest, mothball, reactivate and exit the ethanol market, considering uncertainty and volatility in the market price of ethanol and irreversible investment.

**Materials and methods**

- A real options analysis (ROA) is employed to compute the prices of ethanol that trigger entry into and exit from the ethanol market.

**Data and Assumption**

- Plant capacity: 20 million gallon per year
- Output: Ethanol, Stillage powder and Beet pulp
- Ethanol price data: 1996 to 2014 (monthly)

**I Baseline Findings**

- Considering the volatility of ethanol price, ethanol investors should call to ethanol investment when the price of ethanol is 2.87 $/gal, once entered they can stay in producing ethanol until price reach to 1.03 $/gal (Table 1).
- The trigger exit price, 1.03 $/gal, was below the net operating cost of 1.43 $/gal, an indication that once the investment is made, the firm will not abandon the project unless the exit price is sufficiently far below the net operating cost.
- The mothball trigger price was 1.03 $/gal, relatively equal to the exit price, indicating that the owner of the refinery prefers an exit option directly, rather than mothballing because mothballed plants require maintenance costs for future reactivation.
- Only a small period of the time that the real options entry price is above the market Price of ethanol since 2005 an indication that there were few time periods that would have supported beat ethanol plant investment (Figure 1).

**Table 1 Baseline real options trigger prices**

<table>
<thead>
<tr>
<th>Price</th>
<th>$/gallon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry price</td>
<td>2.87</td>
</tr>
<tr>
<td>Reactivation price</td>
<td>1.91</td>
</tr>
<tr>
<td>Mothballing price</td>
<td>1.03</td>
</tr>
<tr>
<td>Exit price</td>
<td>1.03</td>
</tr>
<tr>
<td>NPV Entry</td>
<td>1.69</td>
</tr>
<tr>
<td>Exit</td>
<td>1.36</td>
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</tbody>
</table>

**II. Effects of ethanol market price volatility**

- With a modest change in ethanol price uncertainty, for example, a change from 0.08 to 0.16, (fig 2) the zone of inaction (i.e., the distance between the entry and exit trigger prices) increased from 0.72 to 1.12 $/gal, implying that even a small increase in uncertainty impacts prices.

**Figure 2.**

- The firm would abandon at a higher threshold exit price because it will lose more money when operating costs are higher. The expected flow of profit from, and hence the option value of the plant, falls as the beet price increases, implying that higher ethanol prices are required before the firm is willing to invest.

**III. Effects of beets price variability**

At beet prices greater than 35 $/ton, the entry trigger price exceeds the 3 $/gal mark. At 55 $/ton, entry trigger prices were above 4 $/gal. Higher beet prices imply higher operating costs, which decrease the value of the ethanol plant, and increase the trigger price required to invest (Fig 3).

In addition, the firm would abandon at a higher threshold exit price because it will lose more money when operating costs are higher. The expected flow of profit from, and hence the option value of the plant, falls as the beet price increases, implying that higher ethanol prices are required before the firm is willing to invest.

**Figure 3.**

**Conclusions**

- Under the current market prices of conventional ethanol, the prospect of beet ethanol plant entry into the ethanol market seems uncertain given the trigger entry prices were significantly higher than wholesale market price.
- From the perspective of the current ethanol market situation, uncertainty about feedstock costs coupled with volatility in ethanol prices and higher plant investment costs can be a significant barrier to investment in such small energy beet ethanol plants.
- The future investment outlook for energy beet ethanol might be more promising and enhanced if feedstock and ethanol market conditions improve, and policy interventions thru federal or state ethanol subsidies or tax incentives.
- Ethanol from energy beets could play a key role and contribute to achieving some of the objectives of the RFS at a time when progress on cellulosic ethanol lags behind proposed schedules and the mandated volumetric requirement under the RFS.
- The trigger prices computed may vary depending on the assumptions we made on prices, cost and approach, ROA that accounts volatility in both revenue and cost, and policy parameter may give a rubout results.

**Further information**

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**Literature cited**
