ACE 427
Spring 2012

Lecture 7

Forecasting Crop Prices Using Fundamental Analysis: Maximum Bid Price Models

by
Professor Scott H. Irwin

Required Reading:

Babcock B.A. “Mandates, Tax Credits, and Tariffs: Does the U.S. Biofuels Industry Need Them All?” CARD Policy Brief 10-PB 1, March 2010. (Class website)
Introduction

The most basic question in ______ analysis is the ______ a prospective buyer (user) is willing to pay for a unit of the commodity

For at least the last 50 years the ______ determinant of the fundamental value of corn has been the value placed on corn by _____________

“Master Model of Midwestern Agriculture,” Hieronymus, Good and Hinton (1980) state:

The price of feed is determined by livestock feed demand, feed production, exports, and food and industrial uses. The lines of causation are from consumer demand through the livestock sector to feed prices. If a basic relationship between livestock and feed prices can be identified, we can then develop a concept of what feed is really worth. Then the price of feed at a given time can be judged as above or below its equilibrium value. We should not expect much stability in this relationship. The supply of feed available varies substantially from year to year because of production changes and variation in other demands, particularly for export. The livestock industry is not confronted with a stable feed supply but must continually adjust to variation.
Figure 3-10, Master Model of Midwest Agriculture
The boom in _____________ has caused a significant change in the basic economics of the crop sector.
How is Ethanol Made? Dry Milling

In dry milling, the entire corn kernel or other starchy grain is first ground into flour, which is referred to in the industry as "meal" and processed without separating out the various component parts of the grain. The meal is slurred with water to form a "mash." Enzymes are added to the mash to convert the starch to dextrose, a simple sugar. Ammonia is added for pH control and as a nutrient to the yeast.

The mash is processed in a high-temperature cooker to reduce bacteria levels ahead of fermentation. The mash is cooled and transferred to fermenters where yeast is added and the conversion of sugar to ethanol and carbon dioxide (CO2) begins.

The fermentation process generally takes about 40 to 50 hours. During this part of the process, the mash is agitated and kept cool to facilitate the activity of the yeast. After fermentation, the resulting "beer" is transferred to distillation columns where the ethanol is separated from the remaining "stillage." The ethanol is concentrated to 190 proof using conventional distillation and then is dehydrated to approximately 200 proof in a molecular sieve system.

The anhydrous ethanol is then blended with about 5% denaturant (such as natural gasoline) to render it undrinkable and thus not subject to beverage alcohol tax. It is then ready for shipment to gasoline terminals or retailers.

The stillage is sent through a centrifuge that separates the coarse grain from the solubles. The solubles are then concentrated to about 30% solids by evaporation, resulting in Condensed Distillers Solubles (CDS) or "syrup." The coarse grain and the syrup are then dried together to produce dried distillers grains with solubles (DDGS), a high quality, nutritious livestock feed. The CO2 released during fermentation is captured and sold for use in carbonating soft drinks and beverages and the manufacture of dry ice.

Source: Renewable Fuels Association (http://www.ethanolrfa.org/resource/made/)
How is Ethanol Made? Wet Milling

In wet milling, the grain is soaked or "steeped" in water and dilute sulfurous acid for 24 to 48 hours. This steeping facilitates the separation of the grain into its many component parts.

After steeping, the corn slurry is processed through a series of grinders to separate the corn germ. The corn oil from the germ is either extracted on-site or sold to crushers who extract the corn oil. The remaining fiber, gluten and starch components are further segregated using centrifugal, screen and hydroclonic separators.

The steeping liquor is concentrated in an evaporator. This concentrated product, heavy steep water, is co-dried with the fiber component and is then sold as corn gluten feed to the livestock industry. Heavy steep water is also sold by itself as a feed ingredient and is used as a component in Ice Ban, an environmentally friendly alternative to salt for removing ice from roads.

The gluten component (protein) is filtered and dried to produce the corn gluten meal co-product. This product is highly sought after as a feed ingredient in poultry broiler operations.

The starch and any remaining water from the mash can then be processed in one of three ways: fermented into ethanol, dried and sold as dried or modified corn starch, or processed into corn syrup. The fermentation process for ethanol is very similar to the dry mill process described above.

Source: Renewable Fuels Association (http://www.ethanolrfa.org/resource/made/)
Maximum Bid Price

Assume that the ethanol industry is the __________ bidder for corn

Maximum bid price model can be constructed based on a ________________ constraint

- Long-run: determine the ________________ that ethanol processors can pay after meeting fixed and variable costs of production plus a normal economic return

- Short-run: determine the ________________ that ethanol processors can pay after meeting variable costs of production

- Assume that ____________ will force ethanol processors to _______ the price of corn to the break-even level in the short- and long-run

Must have a good economic model of an __________ or ______________ ethanol plant for this approach to be useful
Representative Ethanol Plant Model

A number of ________ models of ethanol plants have been constructed

A 2009 study at the University of Nebraska is a good starting point

- Surveyed 7 recently constructed ethanol plants for their production and cost information in 2006 and 2007

- One plant each in Nebraska, South Dakota, Minnesota, Iowa, Missouri, Wisconsin, and Michigan

- Provides _____ rather than __________ data on technical production coefficients and input costs

Key survey results:

- Average operating capacity: 53.1 million gallons of ethanol production annually
• Output efficiency for each bushel of corn processed:

➤ ______ gallons of pure ethanol (E100)

➤ ______ pounds distillers dried grain with solubles (DDGS) at 10% moisture

• Variable non-corn operating costs: ________ of corn processed

• We will use these results as the starting point for our __________ ethanol plant model

➤ 100 million gallons annual ethanol production

➤ ______ gallons of ethanol per bushel of corn processed

➤ ______ pounds of DDGS per bushel of corn processed

➤ Implies 35.7 million bushels of corn processed annually by plant
$1.00/bu. variable non-corn operating costs per bushel of corn processed (based on drop in natural gas prices)

The next step is to make some assumptions about ______________ and ____________ in order to compute ____________

Lacking any better information, we are going to use the fixed costs from another model in use at Iowa State University:

- Assumes plant construction costs are ______ per gallon of ethanol production capacity
- 40% debt and 60% equity financing
- 8.25% interest on 10-year loan for debt financing

Fixed Costs

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Depreciation</td>
<td>$0.3076/bu.</td>
</tr>
<tr>
<td>Interest</td>
<td>$0.1774/bu.</td>
</tr>
<tr>
<td>Labor &amp; management</td>
<td>$0.1064/bu.</td>
</tr>
<tr>
<td>Property taxes</td>
<td>$0.0064/bu.</td>
</tr>
<tr>
<td>Total</td>
<td>$0.5978/bu.</td>
</tr>
</tbody>
</table>
To complete the model we need an estimate of the ___________________ required by the equity investors in the plant

This is the most __________ part of the model

We will follow other studies and simply assume that a __________ is required to compensate equity investors

- Assuming our plant is operating at capacity, it will use _____ million bushels of corn annually (100 million gallons of ethanol/2.8 gallons of ethanol per bushel of corn processed)

- The 50% equity investment of the plant owners is assumed to be __________ ($2.11/gallon of capacity x 100 million gallons x 60%)

- A 12% annual return is $15.2 million per year

- We want to express this per bushel of corn processed, which is ____________ ($15.2 million per year/35.7 million bushels)
Now we can summarize the cost estimates in our ethanol plant model

Total ______ costs per bushel of corn processed (18.6 million bushels annually):

<table>
<thead>
<tr>
<th>Type</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>$1.00/bu.</td>
</tr>
<tr>
<td>Fixed</td>
<td>$0.59/bu.</td>
</tr>
<tr>
<td>12% Return</td>
<td>$0.30/bu.</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>______</td>
</tr>
</tbody>
</table>

**Computing the Maximum Bid Price**

We are now ready to return to our original purpose, which is computing the ______________ that an ethanol plant can _____ for the price of corn in the short- and long-run

To do this, we will combine information on the market price of ______ and ______ with our plant ____ estimates to imply maximum bid prices for corn

Basic idea: compute __________ from processing a bushel of corn and then subtract all __________ to infer a maximum bid price for corn
We will use data for March 2, 2012 as an example

Ethanol price at Iowa plants: $2.10/gal.
DDGS price at Iowa plants: $201.50/ton

Ethanol
$2.10/gal x 2.8 gal./bu. = ________

DDGS
$201.55/ton/2,000 x 17 lbs./bu. = ________

Gross Revenue: ________

**Short-Run**

Maximum bid price (breakeven) corn price in the short-run is simply ________ minus ________

Remember the ________ rule from supply theory: a firm will continue operating in the short-run so long as they can at least cover all variable operating costs
Thus, for existing ethanol plants we estimate the maximum short-run bid price for corn on March 2, 2012 as

\[
\begin{align*}
\text{Gross revenue} & \quad \underline{} \\
\text{Variable costs} & \quad \underline{} \\
\text{Max SR bid} & \quad \underline{} \\
\end{align*}
\]

In other words, given current ethanol and DDGS prices, the representative ethanol plant will cease producing for any corn price above \underline{}.

**Long-Run**

Maximum bid price (breakeven) corn price in the long-run is simply gross revenue minus \underline{} \\
\underline{}.

This will estimate the maximum price that an ethanol plant can pay for corn and \underline{} over the longer-term.

\[
\begin{align*}
\text{Gross revenue} & \quad \underline{} \\
\text{Variable costs} & \quad \underline{} \\
\text{Fixed costs} & \quad \underline{} \\
12\% \text{ return} & \quad \underline{} \\
\text{Max LR bid} & \quad \underline{} \\
\end{align*}
\]
An alternative interpretation is that, given current ethanol and DDGS prices, the maximum price of corn to attract new ________ into the ethanol industry is ________

**Maximum Bid Prices Over Time**

We can apply our economic model of a representative ethanol plant to time-series of ethanol and DDGS prices to determine how well actual corn prices ________ bid prices

A couple of tweaks to the model:

1. Allow non-corn variable costs to adjust to natural gas costs, the biggest component of variable operating costs

![Natural Gas Cost per Bushel of Corn Processed at Iowa Ethanol Plants, 01/27/07- 03/02/2012](image-url)
2. When computing maximum bid price we allow the price of DDGS to move with the bid price

**Weekly Ratio of DDG to Corn Price at Iowa Ethanol Plants, 01/27/07- 03/02/2012**

**Notes on calculations:**

Use Iowa Ethanol Report data on ethanol and DDGS prices since this is the longest series of publically available data.

Compute each week (Friday) maximum bid prices based on that week’s ethanol and DDGS prices.

Compare the bid prices to the price of corn at Iowa ethanol plants.
Weekly Price of Corn and Maximum Bid Price at Iowa Ethanol Plants, 01/27/07 - 03/02/2012

Maximum Bid Price (variable costs only)

Maximum Bid Price (all costs, 0% ROE)
Conclusions

_________ of ethanol plants does ______ the price of corn since the beginning of the 2007/08 marketing year

Maximum bid prices assuming ______ or including cost plus a normal economic return provide the best fit for corn prices

Relationship is far from ________!
Ethanol Pricing Model

The previous analysis establishes that ____________ is now a primary ____________ of corn prices.

The relationship between maximum bid prices and corn prices provides a ____________ for predicting ____________ price movements.

We still need a way to ____ estimates of energy value to the 2012/13 season average price of corn.

- One alternative is to forecast the _______ that determine energy value for each month of the 2012/13 marketing year, calculate maximum bid prices for each month, and then take a weighted-average (similar to the futures model) of the monthly maximum bid prices.

- This requires forecasts of ________________ ____________gas prices.

There is a simpler approach that may actually be more accurate (remember the principle of parsimony!)

Assuming the cost estimates are representative, then the ____ variable in forecasting the ____________ price of corn is the ________ price

Ethanol Price at Iowa Plants, 01/26/07 - 03/02/2012
The relationship of corn prices and ethanol prices can be illustrated directly.

**Weekly Ethanol and Corn Prices at Iowa Plants, 01/27/07 - 03/02/2012**

**Ethanol/Corn Price Ratio at Iowa Plants, 01/26/07 - 03/02/2012**
**Implication**: The relationship between the price of ___________ may be useful in forecasting the price of ________

Main drivers of ethanol value:

- ___________ (MTBE): price premium

- ______ direct competition with gasoline, ethanol contains 2/3 the BTUs of regular unleaded gasoline

- ___________ $0.45 cent/gallon federal income tax credit to gasoline blenders for blending ethanol with unleaded gasoline [ended December 31, 2011]

- ______________________ set minimum national standards for blending of ethanol with unleaded gasoline
As we studied in the last lecture, the _________ is one widely-used source of forecasts.
With this information and a few more tweaks we can complete our ethanol pricing model

\[ y = 0.0004x - 14.352 \]

\[ R^2 = 0.4348 \]
## Ethanol Pricing Model for 2012/13 Corn

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep-12</td>
<td>Oct-12</td>
<td>2.19</td>
<td>-0.08</td>
<td>2.11</td>
<td>0.03</td>
<td>4.88</td>
<td>7.1</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>Oct-12</td>
<td>Nov-12</td>
<td>2.15</td>
<td>-0.08</td>
<td>2.07</td>
<td>0.03</td>
<td>4.78</td>
<td>12.3</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>Nov-12</td>
<td>Dec-12</td>
<td>2.13</td>
<td>-0.08</td>
<td>2.05</td>
<td>0.03</td>
<td>4.75</td>
<td>12.1</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>Dec-12</td>
<td>Jan-13</td>
<td>2.12</td>
<td>-0.08</td>
<td>2.04</td>
<td>0.03</td>
<td>4.72</td>
<td>9.0</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>Jan-13</td>
<td>Feb-13</td>
<td>2.12</td>
<td>-0.08</td>
<td>2.04</td>
<td>0.03</td>
<td>4.71</td>
<td>14.3</td>
<td>0.67</td>
<td></td>
</tr>
<tr>
<td>Feb-13</td>
<td>Mar-13</td>
<td>2.12</td>
<td>-0.08</td>
<td>2.04</td>
<td>0.03</td>
<td>4.71</td>
<td>6.6</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>Mar-13</td>
<td>Apr-13</td>
<td>2.12</td>
<td>-0.08</td>
<td>2.04</td>
<td>0.03</td>
<td>4.71</td>
<td>7.7</td>
<td>0.36</td>
<td></td>
</tr>
<tr>
<td>Apr-13</td>
<td>May-13</td>
<td>2.12</td>
<td>-0.08</td>
<td>2.04</td>
<td>0.03</td>
<td>4.71</td>
<td>6.1</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>May-13</td>
<td>Jun-13</td>
<td>2.12</td>
<td>-0.08</td>
<td>2.04</td>
<td>0.03</td>
<td>4.71</td>
<td>5.9</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>Jun-13</td>
<td>Jul-13</td>
<td>2.12</td>
<td>-0.08</td>
<td>2.04</td>
<td>0.03</td>
<td>4.71</td>
<td>6.4</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Jul-13</td>
<td>Aug-13</td>
<td>2.12</td>
<td>-0.08</td>
<td>2.04</td>
<td>0.03</td>
<td>4.71</td>
<td>6.8</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>Aug-13</td>
<td>Sep-13</td>
<td>2.12</td>
<td>-0.08</td>
<td>2.04</td>
<td>0.03</td>
<td>4.71</td>
<td>5.8</td>
<td>0.27</td>
<td></td>
</tr>
</tbody>
</table>

US Average Farm Price Forecast from Ethanol Model: 4.74
US Average Farm Price from Ending Stocks Model: 4.17
US Average Farm Price from Futures Model: 5.23
Comparison of 2012/13 Forecasts

We now have two different estimates of the ______________ of corn for the 2012/13 marketing year

- Ethanol Model: $4.74/bu.
- Which one is __________

Forecasting research over the last 30 years indicates a surprising answer

- __________ likely contain useful information not found in the other

- A ____________ of the two forecasts is likely to be more accurate than either of forecasts separately

- This is called a _____________ forecast

- Very large literature showing that this approach is very ______________ in terms of accuracy
With that background, our new estimate of the fundamental value of corn for 2012/13 is:

\[
\frac{($4.17 + $4.74)}{2} = $4.46/\text{bushel}
\]

Given a futures price model forecast of ________, we remain ________ on 2012/13 corn prices using this composite approach.

Final Point:

- The maximum bid approach can be applied to other users of corn.
- For example, we could compute the price of corn that hog producers could afford to pay and just cover all variable costs.
- Basic idea is the same. First project gross revenue per finished hog and then subtract non-corn variable costs of production.