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Is irrigated farm is more efficient than non-irrigated non-pillage farm and non-irrigated conventional farm for a sample of Kansas corn farmer?

Rulianda P Wibowo¹ and Allen M Featherstone²

¹ Ph.D. Candidate, ² Professor, Department of Agricultural Economics, Kansas State University

Background

The corn farmer has benefited from high corn price. However, the corn price plunged from its high price in 2012 to as low as $ 4.46 per bushel in 2013. The drop in corn price and intense competition from the global grain markets make farms that are non-efficient struggle economically. A sample of Kansas Farm Management Association (KFMA) data for corn farmers showed that the gross income per acre, variable cost per acre, and total profit per acre of irrigated farm, non-irrigated conventional farm and non-irrigated non-pillage farm were steadily increasing from 2007 to 2012. The rate of increase is higher for non-irrigated non-pillage farms than irrigated farms and non-irrigated conventional farms (KFMA, 2013). Moreover, the change in profit per acre over the years is found to be positive for irrigated farms but negative for non-irrigated conventional farms and non-irrigated non-pillage farms. Thus, it implies that non-irrigated non-pillage farms were more reliant on corn price for its profitability. During the corn price drop in 2013, non-irrigated non-pillage farms were facing higher losses than irrigated farms. There is profit variability among three methods of corn farming. Whether the variability is caused by production inefficiency or economies of scale needs further analysis. We are expecting that non-irrigated non-pillage farms and non-irrigated conventional farms are less efficient than irrigated farms. This may contradict with the finding of Belchakov et al. (2016) that regions with lower revenue per hectare have more stable revenue per hectare, while regions with higher land productivity experienced higher variation revenue per hectare.

Objectives and Motivation

• To examine the differences in efficiency among irrigated farm, non-irrigated non-pillage farm and non-irrigated conventional farm. The comparison between the three farm types will examine which production method is more efficient.
• To examine the efficiency for 2011, 2012, and 2013. The comparison of efficiency between 2011, 2012, and 2013 will provide explanation of cost minimization behavior of each type of corn farm when it is facing high corn price and low corn price. The efficiency comparison between 2011 and 2012 will present intuition regarding the 2012 drought.
• To examine the correlation between farm characteristics and efficiency.
• To analyze the correlation between input use and efficiency. The correlation will identify the importance of each input to efficiency.

Model

Data Envelopment Analysis (DEA)

The nonparametric approach proposed by Färe et al. (1985) was used to measure pure technical efficiency, overall technical efficiency and scale efficiency. The advantage of the non-parametric approach compare to parametric approach is it can easily solve for disaggregated inputs (Chavas and Aliber, 1993). The primal method is used to determine the efficiency measures. The primal approach is referred as data envelopment analysis.

The linear programming for PTE:

\[ \text{minimize} \quad \sum_{j=1}^{n} \theta_j x_{j1} - \sum_{j=1}^{n} \theta_j x_{j2} \]

subject to \( \sum_{j=1}^{n} \sum_{k=1}^{m} \theta_j y_{jk} = \sum_{k=1}^{m} \theta_j z_{jk} \), \( \theta_j x_{j1} - \sum_{j=1}^{n} \theta_j x_{j2} \geq 0 \)

where \( y_{jk} \) is output \( k \), \( x_{j2} \) is input \( j \)

The linear programming for OTE:

\[ \text{minimize} \quad \sum_{j=1}^{n} \theta_j x_{j1} - \sum_{j=1}^{n} \theta_j x_{j2} \]

subject to \( \sum_{j=1}^{n} \sum_{k=1}^{m} \theta_j y_{jk} = \sum_{k=1}^{m} \theta_j z_{jk} \), \( \theta_j x_{j1} - \sum_{j=1}^{n} \theta_j x_{j2} \geq 0 \)

where \( y_{jk} \) is output \( k \), \( x_{j2} \) is input \( j \)

The Scale Efficiency (SE) is calculated by

\[ \frac{OTE_j}{PTE_j} \]

Results

Table 1. Efficiency measures for irrigated farm, non-irrigated non-pillage farm and non-irrigated conventional farm (2011, 2012, and 2013)

<table>
<thead>
<tr>
<th>Year</th>
<th>Scale Efficiency</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OTE</td>
<td>PTE</td>
<td>OTE</td>
<td>PTE</td>
</tr>
<tr>
<td>2011</td>
<td>0.55</td>
<td>0.67</td>
<td>0.67</td>
<td>0.67</td>
</tr>
<tr>
<td>2012</td>
<td>0.48</td>
<td>0.44</td>
<td>0.44</td>
<td>0.44</td>
</tr>
<tr>
<td>2013</td>
<td>0.75</td>
<td>0.65</td>
<td>0.65</td>
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</tr>
</tbody>
</table>

Table 2. Relationship among efficiency and farm characteristics

<table>
<thead>
<tr>
<th>Year</th>
<th>Dependent Variable</th>
<th>PTE</th>
<th>OTE</th>
<th>SE</th>
<th>Percentage of owner's equity of total income</th>
<th>Percentage of insurance expenditure to total revenue</th>
<th>Percentage of interest payment to total expense</th>
<th>Land</th>
<th>Labor</th>
<th>Equipment</th>
<th>Machine</th>
<th>Seed</th>
<th>Fertilizer</th>
<th>Herbicide Insecticide</th>
<th>Miscellaneous</th>
<th>Ratio Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>0.0014</td>
<td>0.012</td>
<td>0.012</td>
<td>0.0014</td>
<td>0.571***</td>
<td>0.563***</td>
<td>0.687***</td>
<td>0.0014</td>
<td>0.012</td>
<td>0.0014</td>
<td>0.0014</td>
<td>0.0014</td>
<td>0.0014</td>
<td>0.0014</td>
<td>0.0014</td>
<td>92.10***</td>
</tr>
<tr>
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<td>0.0014</td>
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<td>0.0014</td>
<td>0.0014</td>
<td>92.10***</td>
</tr>
</tbody>
</table>

Table 3. Relationship among efficiency and inputs used

<table>
<thead>
<tr>
<th>Year</th>
<th>Dependent Variable</th>
<th>PTE</th>
<th>OTE</th>
<th>SE</th>
<th>Land</th>
<th>Labor</th>
<th>Equipment</th>
<th>Machine</th>
<th>Seed</th>
<th>Fertilizer</th>
<th>Herbicide Insecticide</th>
<th>Miscellaneous</th>
<th>Ratio Test</th>
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<td>0.687***</td>
<td>0.0014</td>
<td>0.012</td>
<td>0.0014</td>
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<td>0.0014</td>
<td>0.0014</td>
</tr>
<tr>
<td>2012</td>
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<td>0.012</td>
<td>0.0014</td>
<td>0.571***</td>
<td>0.563***</td>
<td>0.687***</td>
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<td>0.012</td>
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<td>0.0014</td>
<td>0.0014</td>
</tr>
<tr>
<td>2013</td>
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<td>0.012</td>
<td>0.012</td>
<td>0.0014</td>
<td>0.571***</td>
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<td>0.012</td>
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<td>0.0014</td>
<td>0.0014</td>
<td>0.0014</td>
</tr>
</tbody>
</table>

Conclusion

• The averages of overall technical efficiency for every farm type across the years are less than 0.70.
• Irrigated farms are more efficient than non-irrigated non-pillage farms and non-irrigated conventional farms.
• Farmers increase their efficiency during drought in 2012.
• Farmers have higher efficiency when they encountered lower corn price.
• There is negative correlation between efficiency and government payments.
• There is negative correlation between efficiency and insurance expenditures. Farmers who purchase higher level of insurance tend to be less efficient.
• Land and labor tend to be over-utilized, whereas seed, fertilizer and fuel/energy tend to be underutilized. Thus the efficiency can be improved by using less land and labor, or more seed, fertilizer and fuel/energy.