ECONOMIC FEASIBILITY OF AUTONOMOUS VEHICLES

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Goals

- Autonomous machinery in main stream media
- Current philosophy on autonomous farm machinery
- Address the economic feasibility of autonomous machinery
- Encourage collaboration to evaluate other autonomous prototypes
Driverless cars will be on UK roads by 2021, says government

These Two Companies Are Making Autonomous Cars Safer On The Road

Ford to deploy up to 100 autonomous cars by the end of 2019, expand testing to third city

Uber Has Spent More Than $1 Billion on Driverless Cars

Kroger’s autonomous delivery cars latest salvo in Houston grocery wars
Driverless tractors are here to help with the severe labor shortage on farms

Robots Take the Wheel as Autonomous Farm Machines Hit the Field

On the autofarm: China turns to driverless tractors, combines to overhaul agriculture
Autonomous Philosophy

1. Small robots that perform specific tasks and work in fleets (swarms)

Fendt (AGCO) “Xaver”

Naio Technologies Weeding Robot
2. Medium autonomous tractor capable of multiple tasks via implement attachments working in fleets (similar to commercial tractor)

SmartFarm Robotics

SeedMaster – “DOT”
Autonomous Philosophy

3. Large autonomous tractor capable of multiple tasks via implement attachments (e.g. leader follower with grain cart and harvester)

Case IH – Autonomous Concept Vehicle

New Holland – NH Drive
Economic Implications of Autonomous Machinery

- Profitability
- Labor markets
- Economies of size
- Capital labor substitution
- Environmental quality
- Rural development
- Sociological dynamics
- Farm safety
- Legal implications
- Risk
Motivation

• Regardless of philosophy, for the most part autonomous machinery is still in the prototype/concept stage
• Opportunity rarely presents itself where economics can influence initial development of a technology
• Evaluate the costs and benefits required to compete with conventional machinery
• One of the largest challenges facing machinery industry: HOW MUCH TO INVEST IN THE DEVELOPMENT OF INTELLIGENT CONTROLS?
  – Will be most costly component of autonomous machinery
  – Highly dependent on the economic benefits
An economic feasibility assessment of autonomous field machinery in grain crop production

Jordan M. Shockley, Carl R. Dillon & Scott A. Shearer

Additional information:

Precision Agriculture
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ISSN 1385-2256
Precision Agric
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Questions

1. Can autonomous machines be an economically viable alternative to conventional agricultural machinery?

2. Since the costs of intelligent controls required is unknown, what is the maximum price that manufactures can charge for intelligent controls and a producer be indifferent between conventional and autonomous machinery?
Specific Objectives

- Determine the optimal number of autonomous machinery
- Determine the break-even investment price for intelligent controls
- Incorporate anticipated economic benefits from autonomous machinery
Optimal Crop Mix

What? When? How much?

Working Days

Crop Sales

Machinery Data

Economic Data

Yield Data

Machinery Selection

Whole Farm Model

Objective

Maximization

Profit
Case Analysis Framework

• 2,100 ac. Kentucky farm producing corn and soybeans under no-till conditions
• Machinery Operations
  – Planting
  – Nitrogen application
  – Herbicide and insecticide treatments
  – Harvest and the application of phosphorus, potassium and lime were assumed custom hired
Conventional Machinery Options

- Tractor: 105 hp, 130 hp, 190 hp, 300 hp, 400 hp
- Sprayer (Broadcast): 27 ft., 40 ft., 50 ft., 60 ft., 90 ft., 120 ft.
- No-Till Split-Row Planter: 4-row, 6-row, 8-row, 12-row, 16-row, 24-row
- Liquid Fertilizer Applicator: 6-row, 8-row, 12-row

- All data were compiled from the Mississippi State Budget Generator (operating costs, ownership costs, and performance rates)
- 13 hour work day assumed
Autonomous Prototype Data

- Cost Data
  - $24,543 for tractor + implement costs
  - ???: Intelligent controls for automation
- 24 hour work day, no operator labor assumed
- Benefits: 10% reduction in inputs costs and 7% yield increase due to reduced compaction
- Not modeled:
  - Additional labor for refilling seed, chemical, and fertilizer or transporting from field to field
  - Opportunity cost associated with switch to autonomous
  - Implementation costs (e.g. insurance, legal, product support, and subscription costs)
## Autonomous Prototype Data

<table>
<thead>
<tr>
<th></th>
<th>46 hp UKAT II Tractor</th>
<th>4-Row Planter</th>
<th>20 ft. Sprayer w/ 400 gal tank</th>
<th>25 ft. Spinner Spreader w/ 2 ton box</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Ownership Cost</td>
<td>$24,543</td>
<td>$6,000</td>
<td>$7,500</td>
<td>$13,000</td>
</tr>
<tr>
<td>Implement Specifications</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed (mph)</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Width (ft.)</td>
<td>10</td>
<td>20</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Efficiency (%)</td>
<td>70</td>
<td>80</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Field Capacity (ac/hr.)</td>
<td>4.2</td>
<td>15.5</td>
<td>18.2</td>
<td></td>
</tr>
<tr>
<td>Tractor Fuel Usage (gal/hr.)</td>
<td>2.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repairs and Maintenance (%)</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Useful Life (years)</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Annual Usage (hours)</td>
<td>600</td>
<td>200</td>
<td>150</td>
<td>150</td>
</tr>
</tbody>
</table>
# Machinery Selection Results

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Conventional Base</th>
<th>Autonomous Benefits Assumed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Benefits</td>
<td>10% Cost Decrease</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7% Yield Increase</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost and Yield Benefits</td>
</tr>
<tr>
<td>Tractor</td>
<td>130 hp</td>
<td>1 – 46 hp</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – 46 hp</td>
</tr>
<tr>
<td>Planter</td>
<td>8-row</td>
<td>1 – 4 row</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – 4 row</td>
</tr>
<tr>
<td>Fertilizer Applicator</td>
<td>8-row</td>
<td>1 – 25 ft.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – 25 ft.</td>
</tr>
<tr>
<td>Sprayer</td>
<td>60 ft.</td>
<td>1 – 20 ft.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – 20 ft.</td>
</tr>
</tbody>
</table>
## Autonomous Economic Results

<table>
<thead>
<tr>
<th></th>
<th>Conventional Base</th>
<th>No Benefits</th>
<th>10% Cost Decrease</th>
<th>7% Yield Increase</th>
<th>Cost and Yield Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Reduction</td>
<td>-</td>
<td>0%</td>
<td>10%</td>
<td>0%</td>
<td>10%</td>
</tr>
<tr>
<td>Yield Increase</td>
<td>-</td>
<td>0%</td>
<td>0%</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>Avg. Annual Net Returns</td>
<td>$600,057</td>
<td>$606,050</td>
<td>$636,979</td>
<td>$688,361</td>
<td>$719,290</td>
</tr>
<tr>
<td>Net Returns Increase Over Conv.</td>
<td>1%</td>
<td>6%</td>
<td>15%</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>Break-even Investment Price</td>
<td>-</td>
<td>$26,128</td>
<td>$160,995</td>
<td>$96,825</td>
<td>$130,737</td>
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<tr>
<td>Production Input Costs</td>
<td>$309,287</td>
<td>$309,287</td>
<td>$278,358</td>
<td>$309,287</td>
<td>$278,358</td>
</tr>
<tr>
<td>Avg. Corn Yield (bu/ac)</td>
<td>163</td>
<td>162</td>
<td>175</td>
<td>175</td>
<td></td>
</tr>
<tr>
<td>Avg. Soybean Yield (kg/ha)</td>
<td>62</td>
<td>62</td>
<td>66</td>
<td>66</td>
<td></td>
</tr>
</tbody>
</table>
Sensitivity Analysis on Farm Size and Increase in Net Returns

Potential profitability on small size farms

- Base Comparison
- 10% Selected Input Reduction
- 7% Yield Increase
- All Anticipated Benefits

Percent Increase in Net Returns Over Conventional Machinery vs. Acres
Sensitivity Analysis on Farm Size and Break-even Investment Price

[Graph showing various lines representing different scenarios with respect to acres and break-even investment price.]

- Base Comparison
- 10% Selected Input Reduction
- 7% Yield Increase
- All Anticipated Benefits
Sensitivity Analysis on Farm Size and Break-even Investment Price @ Moderate Risk Aversion for Days Suitable For Fieldwork
Sensitivity Analysis on Farm Size and Break-even Investment Price with a 25% Increase in Grain Price
We Can Analyze Your Prototype!

**Needs:**
- Cost Data
- Field Performance Data
- Anticipated Benefits
Summary

- Autonomous machinery is here!
- Gaining publicity due to mainstream media and automobile industry
- Where will the industry go?
- Autonomous machinery is feasible IF the price is right
- Small farm profitability potential
- Please contact to analyze your autonomous machinery