Economic Analysis of Farmland Market: An Introduction

Dr. Wendong Zhang
Assistant Professor of Economics
wdzhang@iastate.edu

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A Quick Introduction: Dr. Wendong Zhang

- Grown up in a rural county in NE China
- Attended college in Shanghai and Hong Kong
- Ph.D. in Ag Econ in 2015 from Ohio State
- 2012 summer intern at USDA-ERS on farm economy and farmland values
- Research and extension interests: land value, land ownership, agriculture and the environment, China Ag
Why Care About Farmland Market?

Distribution of U.S. Farm Assets

- Real estate
- Livestock and poultry
- Machinery and motor vehicles
- Crops stored
- Purchased inputs
- Financial assets

Source: USDA ERS
What is the price of corn per bushel now? 2012?

- $2.0
- $7.0
- $3.5
- $4
- $5
Iowa Corn Prices vs. Costs

Source: Chad Hart
The percentage change in Iowa farmland values since Nov 2014?

• Increased 5%
• Increased 10%
• Did not change
• Decreased 5%
• Decreased 10%
Iowa Farmland Values

all farmland 1950–2015

Nominal vs. Inflation Adjusted Iowa Farmland Values

Nominal $7,633
Real As of Nov 15

-3.9%

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% Change in Iowa Farmland Values
1951-2015

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Farmland Values are driven by agricultural market fundamentals

Iowa Farmland Values vs. Commodity Prices 1972-2015

Farmland Values are driven by agricultural market fundamentals.
US Farm Income 1990-2025

Source: USDA OCE
David Ricardo was an English political economist. He was one of the most influential of the classical economists, along with Thomas Malthus, Adam Smith, and James Mill.
Ricardo model

“A” land has lowest production costs = highest rents

“C” land’s rent is 0 because costs are greater than revenue

“A” land

Profit = rent

“B” land

Profit = rent

“C” land

Profit = rent

On fertile land, a farmer can produce the same amount of corn with fewer inputs.
Market Value of Land – Capitalization Formula

\[ PV = \sum_{t=0}^{n} \frac{R}{(1+i)^t} \]

- For simplicity, you could think of land value as the present value of all future annual land rental payments a landowner could charge
- \( PV = \frac{R}{i} \)
Capitalization Formula and Sources of Income

\[ V_{it} = E_t \sum_{s} \frac{R_{is}}{(1 + \delta_t)^{s-t}}, \text{where } s = t, t + 1, \ldots \]

\[ R_{it} = \beta' X_{it} + \tau_t + \eta_{it} \]

\[ V_{it} = E_t \sum_{s} f(A_{is}, N_{is}, U_{is}, M_{is}; \delta_t), \text{where } s = t, t + 1, \ldots \]

- **Agricultural productivity variables** $A_{it}$ such as soil quality
- **Natural amenities variables** $N_{it}$ such as proximity to surface water
- **Urban influence variables** $U_{it}$ such as surrounding urban population, access to highway
- **Agricultural market influence variables** $M_{it}$ such as proximity to ethanol plants, grain elevators and agricultural output terminals
Hedonic pricing model of farmland values

- Log of arm’s length agricultural land prices per acre
  = parcel characteristics (i.e. parcel size)
- + agricultural productivity variables (e.g. soil quality, slope, distances to ethanol plants, grain elevators)
- + agricultural market influence variables
  (distances to ethanol plants, grain elevators, agricultural terminals)
- + agricultural market influence variables * post 2008 indicator
- + urban influence variables
  (e.g. dist to nearest city + additional dist to 2nd city + surrounding urban population + gravity index of 3 nearest cities)
- + year fixed effects
- + spatial fixed effects at census tract level
### Marginal values of farmland characteristics: Agricultural productivity variables

**Agricultural Profitability Influence Variables - Marginal Value**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Marginal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural productivity index (NCCPI)</td>
<td>+ $77.84/ 10% increase</td>
</tr>
<tr>
<td>Prime soil % of parcel</td>
<td>+ $9.3 / 10% increase</td>
</tr>
<tr>
<td>Steep slope</td>
<td>– $203.11/ from non-steep to steep</td>
</tr>
<tr>
<td>Distance to nearest grain elevator</td>
<td>– $15.87 / 1 mile further</td>
</tr>
<tr>
<td>Distance to other agricultural terminal</td>
<td>– $21.04 / 1 mile further</td>
</tr>
</tbody>
</table>
## Marginal values of farmland characteristics: Urban influence variables

<table>
<thead>
<tr>
<th>Urban Influence Variables – Marginal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to nearest city center</td>
</tr>
<tr>
<td>Incremental distance to 2nd nearest city center</td>
</tr>
<tr>
<td>Total urban population within 25 miles</td>
</tr>
<tr>
<td>Distance to highway ramp</td>
</tr>
<tr>
<td>Distance to railway station</td>
</tr>
</tbody>
</table>
Iowa Land Values by County 2015

Dollar Values
- $5,000 or less
- $6,001 to $7,500
- $7,501 to $9,000
- $9,001 to $10,000
- $10,001 or more

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Urban Influence and Farmland Values – Housing Market Bust

Source: Standard & Poor's & FiServ

Source: Standard & Poor
The evolution of urban premium over time

Average Parcel-Level Urban Premium in Ohio 2001-2010

- **Gravity Index of 3 Nearest Cities**
- **Incremental Miles to 2nd Nearest City**
- **Miles to Nearest City**
- **Surrounding Urban Population**
Not Every Iowa County Is Created Equal

Iowa Land Value % Change by County 2014 - 2015

CARD Center for Agricultural and Rural Development
Iowa State University Extension and Outreach
## Land Values by District and Land Quality, 2015

<table>
<thead>
<tr>
<th>District</th>
<th>Average Value</th>
<th>% Change</th>
<th>High Quality</th>
<th>% Change</th>
<th>Medium Quality</th>
<th>% Change</th>
<th>Low Quality</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northwest</td>
<td>$9,685</td>
<td>0.7%</td>
<td>$11,229</td>
<td>0.3%</td>
<td>$8,834</td>
<td>1.6%</td>
<td>$6,252</td>
<td>2.6%</td>
</tr>
<tr>
<td>North Central</td>
<td>$7,962</td>
<td>-6.7%</td>
<td>$8,976</td>
<td>-6.8%</td>
<td>$7,352</td>
<td>-6.6%</td>
<td>$5,372</td>
<td>-1.0%</td>
</tr>
<tr>
<td>Northeast</td>
<td>$7,861</td>
<td>-3.6%</td>
<td>$9,575</td>
<td>-5.0%</td>
<td>$7,460</td>
<td>-1.7%</td>
<td>$5,242</td>
<td>-0.3%</td>
</tr>
<tr>
<td>West Central</td>
<td>$8,061</td>
<td>-4.3%</td>
<td>$9,684</td>
<td>-5.8%</td>
<td>$7,581</td>
<td>-3.2%</td>
<td>$5,082</td>
<td>-1.8%</td>
</tr>
<tr>
<td>Central</td>
<td>$8,505</td>
<td>-6.4%</td>
<td>$10,087</td>
<td>-6.4%</td>
<td>$7,758</td>
<td>-6.8%</td>
<td>$5,292</td>
<td>-5.2%</td>
</tr>
<tr>
<td>East Central</td>
<td>$8,506</td>
<td>-5.6%</td>
<td>$10,289</td>
<td>-6.8%</td>
<td>$7,934</td>
<td>-5.4%</td>
<td>$5,366</td>
<td>-2.1%</td>
</tr>
<tr>
<td>Southwest</td>
<td>$6,372</td>
<td>-2.2%</td>
<td>$8,031</td>
<td>-5.3%</td>
<td>$6,038</td>
<td>-1.2%</td>
<td>$4,070</td>
<td>5.4%</td>
</tr>
<tr>
<td>South Central</td>
<td>$4,397</td>
<td>-1.7%</td>
<td>$6,445</td>
<td>-3.3%</td>
<td>$4,282</td>
<td>-0.8%</td>
<td>$2,750</td>
<td>-2.1%</td>
</tr>
<tr>
<td>Southeast</td>
<td>$6,892</td>
<td>-4.5%</td>
<td>$9,536</td>
<td>-6.0%</td>
<td>$6,525</td>
<td>-2.8%</td>
<td>$3,797</td>
<td>-2.4%</td>
</tr>
<tr>
<td><strong>State Avg.</strong></td>
<td><strong>$7,633</strong></td>
<td><strong>-3.9%</strong></td>
<td><strong>$9,364</strong></td>
<td><strong>-5.0%</strong></td>
<td><strong>$7,127</strong></td>
<td><strong>-3.2%</strong></td>
<td><strong>$4,834</strong></td>
<td><strong>-0.9%</strong></td>
</tr>
</tbody>
</table>
## Livestock and Crop Inventory by District

<table>
<thead>
<tr>
<th>District</th>
<th>Inventory 2012</th>
<th>Harvested Acres 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chickens, Layers</td>
<td>Hogs</td>
</tr>
<tr>
<td>Northwest</td>
<td>30%</td>
<td>26%</td>
</tr>
<tr>
<td>North Central</td>
<td>64%</td>
<td>16%</td>
</tr>
<tr>
<td>Northeast</td>
<td>1%</td>
<td>12%</td>
</tr>
<tr>
<td>West Central</td>
<td>0%</td>
<td>13%</td>
</tr>
<tr>
<td>Central</td>
<td>3%</td>
<td>13%</td>
</tr>
<tr>
<td>East Central</td>
<td>1%</td>
<td>5%</td>
</tr>
<tr>
<td>Southwest</td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>South Central</td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>Southeast</td>
<td>1%</td>
<td>11%</td>
</tr>
<tr>
<td><strong>State Inventory</strong></td>
<td><strong>20.4 million</strong></td>
<td><strong>20.4 million</strong></td>
</tr>
</tbody>
</table>

Source: USDA Ag Census 2012
Farmland Market is Very Thin!

→ Few Observations

Annual Agricultural turnover ratio 2001 - 2010

Blue: <0.5%
Red: 1.5-2%

Illinois <0-3%>
Figure 2. Farmland P/rent Ratio and S&P 500 P/E Ratio, 1960 to 2015.

Source: Purdue University
Baker et al. 2015
Farmland Values vs. Capitalized Land Values

Actual Farmland Values vs. Rent/Interest Rates

- Actual Farmland Values
- Predicted Land Values by Dividing Land Rent over Interest Rate
- Predicted Land Values by Dividing Land Rent over (Interest Rate+0.5%)
- Predicted Land Values by Dividing Land Rent over (Interest Rate+1%)
- Predicted Land Values by Dividing Land Rent over (Interest Rate+2%)

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S&P 500 vs. Farmland Values: A Question of Timing

Source: Mike Duffy
Ag DM Newsletter June 2014

Value of $1,000 invested in 1960 in thousand dollars

Year

1960
S&P 500 vs. Farmland Values: A Question of Timing

Source: Zhang and Duffy
Ag DM Newsletter April 2016

Return to S & P Investment Relative to Iowa Farmland Investment

Source: Zhang and Duffy
Ag DM Newsletter April 2016

Figure 4. Return to an investment in the S&P relative to an investment made in Iowa farmland by year of investment and year of selling that investment.
Iowa Ag Real Estate Values 1850-2015

Source: USDA-NASS; Ag Census
A replay of 1920s or 1980s farm crisis?

<table>
<thead>
<tr>
<th>Golden Eras</th>
<th>Land</th>
<th>Gross Income</th>
<th>Net Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>1910-1920</td>
<td>1.2%</td>
<td>0.8%</td>
<td>0.2%</td>
</tr>
<tr>
<td>1973-1981</td>
<td>9.7%</td>
<td>0.9%</td>
<td>-3.2%</td>
</tr>
<tr>
<td>2003-2013</td>
<td>11.1%</td>
<td>4.5%</td>
<td>8.1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crises and Declines</th>
<th>Land</th>
<th>Gross Income</th>
<th>Net Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>1921-1933</td>
<td>-5.8%</td>
<td>-1.9%</td>
<td>-1.0%</td>
</tr>
<tr>
<td>1981-1987</td>
<td>-15.0%</td>
<td>-2.5%</td>
<td>2.6%</td>
</tr>
<tr>
<td>2013-2016</td>
<td>-6.0%*</td>
<td>-2.7%</td>
<td>-9.5%</td>
</tr>
</tbody>
</table>

Source: USDA-ERS, Ag DM C2-70
Iowa Farmland Value Portal
http://card.iastate.edu/farmland

Your One-Stop Web-Portal for Everything You Need to Know about Iowa’s Farmland Value

Select a county or district: State of Iowa

Select result format: dollar value, annual percentage change, farmland value indexes (state only)

Select data sources: ISU Iowa Land Value Survey, USDA National Agricultural Statistics Service, Federal Reserve Bank of Chicago

Years: 1951 through 2014

Show Values
Show Iowa Average
Show District Average
Iowa Farmland Value Portal

http://card.iastate.edu/farmland
Iowa Farmland Value Portal
www.card.iastate.edu/farmland
If you only remember one thing

• $PV = \frac{R}{I}$
• Land Values = Net Income/Discount Rate

Land Value Depends on the Source of Income
Thank You!

Wendong Zhang
Assistant Professor and Extension Economist
478C Heady Hall
Iowa State University
515-294-2536
wdzhang@iastate.edu
http://www2.econ.iastate.edu/faculty/zhang/
http://card.iastate.edu/farmland/
## Crop Return and Land Value

**Dependent variable:** Iowa annual average land value

<table>
<thead>
<tr>
<th>Explanatory Variable</th>
<th>Coef</th>
<th>Std Err.</th>
<th>T-stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-year average corn return</td>
<td>18.04</td>
<td>1.67</td>
<td>10.78</td>
</tr>
<tr>
<td>Lagged corn return last year</td>
<td>1.73</td>
<td>0.77</td>
<td>2.25</td>
</tr>
<tr>
<td>1-year interest rate</td>
<td>54.66</td>
<td>43.12</td>
<td>1.27</td>
</tr>
<tr>
<td>S&amp;P 500 P/E Ratio</td>
<td>-84.79</td>
<td>13.61</td>
<td>-6.23</td>
</tr>
<tr>
<td>Year Trend</td>
<td>186.05</td>
<td>15.85</td>
<td>11.74</td>
</tr>
<tr>
<td>Intercept</td>
<td>251.3</td>
<td>516.0</td>
<td>0.62</td>
</tr>
</tbody>
</table>

Joint work with Chad Hart
Land Value vs. Prediction

Joint work with Chad Hart
How Ag Professionals Form Land Value Expectations

• Goal: Examine how individual survey respondents formulate current land value expectations and what information they rely on

• Data: a 11-year panel of individual Iowa agricultural professionals’ estimates of current land value – Iowa Land Value Survey 2005-2015
### Farmland Values in Your County as of November 1, 2014*

1. **Values for average-size farms in «CoName» County are:**

<table>
<thead>
<tr>
<th>High grade land</th>
<th>$«High Value»/acre</th>
<th>Present Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium grade land</td>
<td>$«Medium Value»/acre</td>
<td>$__________/acre</td>
</tr>
<tr>
<td>Low grade land</td>
<td>$«Low Value»/acre</td>
<td>$__________/acre</td>
</tr>
</tbody>
</table>

- Annual survey of farm real estate market professionals (e.g., farm managers, appraisers, real estate brokers, assessors, etc.)
- Last year’s individual estimates supplied
- Final result only contains one average county estimate
Empirical strategy

• Examine the influence of prior “error” (deviation between individual and county aggregate)

• Simple model based on important factors, similar to net present value of farmland
  – Income (proxied by commodity prices)
  – Interest rates
  – Sale activity

• Panel Data Individual Fixed Effects Model
Empirical model

- Define annual change at time $t$ for respondent $i$ in county $j$ as:
  \[ \Delta y_{i,j,t}^* = y_{i,j,t}^* - y_{i,j,t-1}^* \]

- The model takes the form:
  \[ \Delta y_{i,j,t}^* = \alpha_i + \gamma(y_{i,j,t-1}^* - \bar{y}_{j,t-1}) + \beta_1 \Delta r_t + \beta_2 \Delta p_t + \beta_3 \Delta v_t + \varepsilon_{i,t} \]

- All variables expressed in natural logs
- $\bar{y}_{j,t-1}$ county-level average value adjusted by Ag Census
- Farm Real Estate interest rate obtained from Chicago Fed

Joint work with Todd Kuethe
University of Illinois
# Results (average)

## Individual fixed effects model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Simple</th>
<th>Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior deviation</td>
<td>-0.860</td>
<td>-0.844</td>
</tr>
<tr>
<td>(y_{i,j,t-1} - \bar{y}_{j,t-1})</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>(0.058)</td>
<td>(0.055)</td>
</tr>
<tr>
<td>Farm loan rate (\Delta r_t)</td>
<td></td>
<td>-0.551</td>
</tr>
<tr>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.044)</td>
</tr>
<tr>
<td>Corn price (\Delta p_t)</td>
<td></td>
<td>0.169</td>
</tr>
<tr>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.017)</td>
</tr>
<tr>
<td>Sale activity (\Delta v_t)</td>
<td></td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.009)</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.334</td>
<td>0.446</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

***\(\alpha \leq 0.01\), **\(\alpha \leq 0.05\), *\(\alpha \leq 0.10\)
Explaining changes in land value estimates over time

• Respondents influenced by prior deviations: 1% increase in the deviation from the county average from last year ➔ 0.84% decrease in this year’s response

• Respondents more responsive in % terms to interest rate changes than commodity price shifts and sale activity changes

• Some heterogeneity in responses across the land quality classes

Joint work with Todd Kuethe
University of Illinois
Future plans

• Alternative regressors
  – Income: five-year average net corn revenue
  – Sale activity: FCS actual sale volume data by crop reporting district
  – True value: average arm’s-length sale prices by county for selected counties

• Related work on expectation formation
  – Adaptive vs. rational vs. extrapolative

Joint work with Todd Kuethe
University of Illinois
% of Farmland by Age and Life Stage of Owners

Source: Ag DM PM1980
Putting Aging Farming Population into Perspective

Figure 2. Average Age of Farmers and Median Age of Labor Force, U.S., 1980-2010

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Age Farmers</th>
<th>Median Age Labor Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982/1980</td>
<td>50.5</td>
<td>34.6</td>
</tr>
<tr>
<td>1992/1990</td>
<td>53.3</td>
<td>36.4</td>
</tr>
<tr>
<td>2002/2000</td>
<td>55.3</td>
<td>39.3</td>
</tr>
<tr>
<td>2007/2010</td>
<td>57.1</td>
<td>41.7</td>
</tr>
</tbody>
</table>

Source: Carl Zulauf, Census of Ag., BLS
Iowa Farmland Purchases by Buyer Types 1986-2015

The graph shows the percentage of farmland purchases by different buyer types from 1989 to 2015. The buyer types include:

- **Existing Farmers** (blue line)
- **Investors** (red dotted line)
- **New Farmers** (green dashed line)
- **Other** (purple line)

The data indicates a trend where the percentage of farmland purchased by existing farmers has generally remained high, with a slight decline around 2002 and a subsequent rise. Investors show a more fluctuating trend, with peaks in 1998 and around 2012. New farmers and other buyer types have lower percentages, with slight variations over the years.