Determinants and consequences of the rise of organic agriculture in the US

Industrial Organization Colloquium
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October 24th, 2018

Outline

Motivation

Modern organic agriculture is

- More financially sustainable for farmers

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	Conventional	Organic
Gross value of production	\$723.35	\$855.80
Operating costs	\$292.50	\$171.63
Allocated overhead	\$279.75	\$322.83
Value of production - operating cost	\$430.85	\$684.17
Value of production - total costs	\$151.10	\$361.34

Table: Corn production costs and returns per planted acre, Heartland region (MO+IL), 2010. Source: US Department of Agriculture (USDA)

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→ Why don't all farmers transition to organic?

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$\rightarrow$ Should we be aiming for a global organic agriculture?

Institutional context

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  "Certified to have grown on soil that had no prohibited substances applied for three years prior to harvest"
- A small market: 5.5% of total food sales, $\sim$ \$45 bn in 2017.
- A growing market: 8 to 10% annual growth since 2000.
- A high-value market: sold with a 10 to 50% price premium compared to conventional food.

Outline

Commercial data

- “The US Department of Agriculture does not have official statistics on U.S. organic retail sales"
- Nielsen provides retail prices and quantities of products (barcode level) sold, by supermarket and by week
  - Barcodes descriptions include mentions of the organic label
- The USDA does provide wholesale prices by product category, by terminal market and by day
- Some wholesale prices from PromoData

Production data

From the USDA:

- Areas grown by crop, by county and by year (surveys)
- Areas grown by crop and organic type, by county and by year (census of Ag)
- Addresses of the 20,000 certified organic farms (National Organic Program)
- Cropland use by 30mx30m squares and by year (National Agricultural Services)
  $\rightarrow$ Raw data from the US Geological service

And weather data: Weather by 4kmx4km squares and by day from the PRISM Climate Group at Oregon State

Regulatory data

- Details about regulation of organic certification
- Details about crop insurance plans available every year in every county
- “Summary of business” of insurance plans i.e. revenue and losses, by county/crop/organic, insurance plan and by year

Outline

Two research questions

1. Is the US food sector increasingly catering to elites at the expense of the poor?
   1.1 What are the determinants of demand for organic food in different consumer markets?
   1.2 Does it negatively affect poorer consumers?
2. Would the US environment benefit from a larger scale transition to organic agriculture?
   2.1 How big is the yield gap in the US?
   2.2 Is there an extensive margin response to profit potential in the organic sector?

Outline

Demand

For now, I estimate a logit demand model:

$$U_{ij} = \delta_j + \epsilon_{ij}, \text{ where}$$

- δ_j is the average taste for product j
- ϵ_{ij} is type I extreme value.

This gives the following share for each product j

$$s_j = \frac{\exp(\delta_j)}{1 + \sum_{q \geq 1} \exp(\delta_q)}$$

Normalizing the outside good: $\delta_0 = 0$, I can estimate:

$$\ln s_j - \ln s_0 = \delta_j = \sum_k \beta_k x_{kj} - \alpha p_j + \xi_j$$

Where x_j, p_j are the characteristics of product j.

Modeling choices

Using Nielsen's scanner dataset, I make the following choices:

- Product: fresh apples (in pounds)
- Market: a store, every week
- Outside good: not buying an apple
- Market size: total customers of the store, proxied by milk purchases (largest retail product category)
- Product characteristics:
  - Organic
  - Variety
  - Grade
- Instrument for price:
  - Wholesale price
  - Hausman instrument

Demand estimation results - 1

In a (very) rich county, there is a taste for the organic characteristic.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Price per pound	-0.35^{***}	-0.48^{***}	-0.23^{***}	-0.38^{***}	-0.80^{***}	-0.31^{***}	-0.38^{***}	-0.85^{***}	-0.36^{***}	-0.51^{***}	-0.26^{*}	-0.56^{***}
	(0.03)	(0.11)	(0.07)	(0.03)	(0.12)	(0.07)	(0.03)	(0.12)	(0.07)	(0.03)	(0.14)	(0.10)
organic				0.80^{***}	0.96^{***}	0.88^{***}	0.83^{***}	1.02^{***}	0.93^{***}	0.01	-0.01	0.18^{*}
				(0.11)	(0.12)	(0.11)	(0.11)	(0.12)	(0.11)	(0.11)	(0.11)	(0.11)
Variety FEs	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Grade FEs	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Store FEs	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes
Instrument	No	W	H	No	W	H	No	W	H	No	W	H
N	4744	4744	4641	4744	4744	4641	4744	4744	4641	4744	4744	4641
r2	0.02	0.02	0.02	0.03	0.00	0.03	0.04	-0.00	0.04	0.32	0.31	0.31

Table: Morris county, New Jersey, median household income of $97,979 (2012 ACS)

Demand estimation results - 2

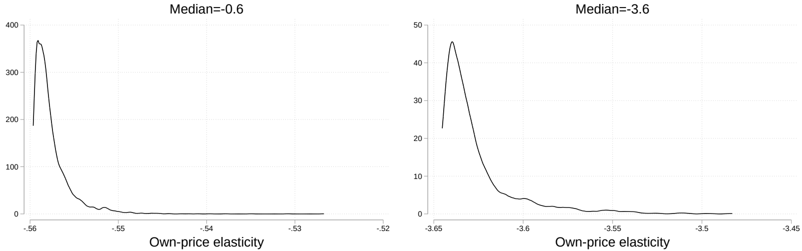
In a poor county, the price sensitivity is much higher and there is no taste for the organic characteristic.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
pricelb	-1.29^{***}	-0.36	-3.10^{***}	-1.26^{***}	0.39	-3.09^{***}	-0.88^{***}	-0.62	-2.82^{***}	-0.97^{***}	-1.44	-3.65^{***}
	(0.08)	(0.54)	(0.26)	(0.08)	(0.72)	(0.27)	(0.08)	(0.53)	(0.48)	(0.08)	(1.07)	(0.69)
organic				-0.72^{***}	-1.34^{***}	-0.25	-0.18	-0.23	0.01	-0.51^{**}	-0.47^{*}	-0.49
				(0.26)	(0.40)	(0.42)	(0.25)	(0.27)	(0.41)	(0.24)	(0.26)	(0.42)
Variety FEs	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Grade FEs	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Store FEs	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes
Instrument	No	W	H	No	W	H	No	W	H	No	W	H
N	1323	1323	1238	1323	1323	1238	1323	1323	1238	1323	1323	1238
r2	0.16	0.08	-0.06	0.17	-0.10	-0.06	0.26	0.26	0.03	0.40	0.39	0.07

Table: De Soto and Hardee counties, Florida, median household income of $\sim$ \$36,000 (2012 ACS)

Price Elasticities

$$\eta = \frac{\partial s}{\partial p}\frac{p}{s} = \alpha(1-s)$$



(a) Morris county

(b) De Soto and Hardee counties

Issues and perspectives

- Iterate this logit model more.
  - Market definition
  - Outside good
- Estimate a BLP model?
- Following Sylvia Hristakeva (2016)'s use of yogurt assortment choice to construct the vertical payments made from producers to retailers by revealed preference.
- I could use produce assortment choice to explore retailers' use of the organic category as a means of price discrimination
- And study welfare implications

Outline

Farmers' supply decision

- Goal: explore farmers' production decision regarding the choice to go organic or not.
- Data: spatial data on fields and crops + organic farms addresses, yearly 2008-2018
- Model: dynamic discrete choice with interactions
- I follow closely Paul T. Scott (2013)'s paper on land use, but with several twists:
    1. Add the decision to produce organic to the crop decision (two state variables)
    2. Consider the decision made by a farm for many fields.
    3. Allow for externalities between fields.

1: The organic state variable

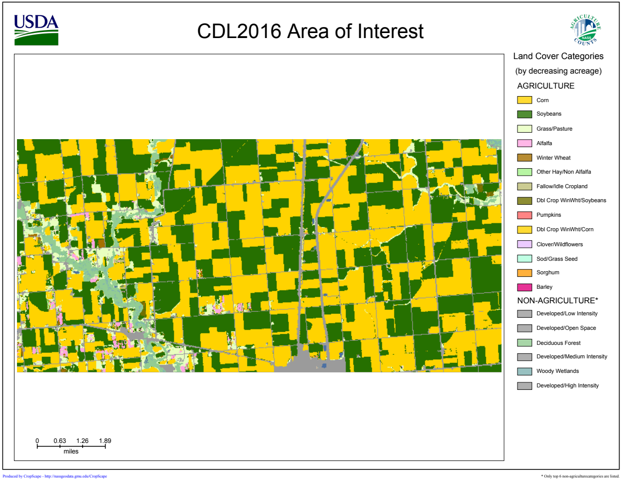
- Given each field's state, farmer must decide (1) how to use the field and (2) if used, whether to follow the organic rules.
- This changes the field's state.
- She can only benefit from organic returns after the field has been grown using the organic technology three years in a row.
- State variable: $s_{ijt} \in \{0, 3\}$ is the number of years the field has been grown using organic technology.

$$s_{t+1} = \begin{cases} \min\{3, s_t + 1\} & \text{if } c_t = 1 \text{ (organic)} \\ 0 & \text{if } c_t = 0 \text{ (conventional)} \end{cases}$$

$$P(s_{t+1}|1, s_t) = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad P(s_{t+1}|0, s_t) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$$

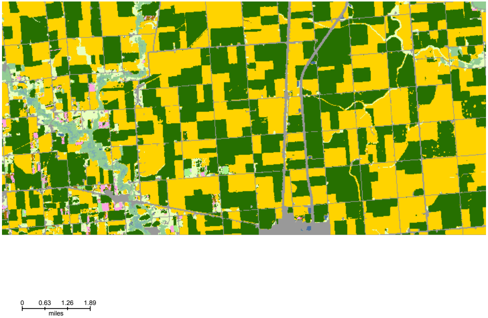
2: Thinking a the farm level

- Use K-means algorithm to find clusters.
- Use the organic farms lists to identify organic farms



USDA

CDL2017 Area of Interest



Land Cover Categories
(by decreasing acreage)

AGRICULTURE

- Soybeans
- Corn
- Grass/Pasture
- Alfalfa
- Other Hay/Non Alfalfa
- Winter Wheat
- Clover/Wildflowers
- Dbl Crop WinWht/Soybeans
- Sod/Grass Seed
- Pumpkins
- Oats
- Fallow/Idle Cropland

NON-AGRICULTURE*

- Developed/Low Intensity
- Developed/Open Space
- Deciduous Forest
- Developed/Medium Intensity
- Woody Wetlands
- Developed/High Intensity

Produced by CropScape - http://nassgeodata.gmu.edu/CropScape

* Only top 6 non-agriculturecategories are listed.

3: Model with Externalities

Expected payoffs to land use j if field i is in state (k,s) at time t:

$$\pi(j,k,s,\omega_t,\mu_{it}) = \alpha_0(j,s,k) + \alpha_R R_j(\omega_t) + \xi_{jks}(\omega_t) + \mu_{jit}$$

- ω_t is the market state
- $R_j(\omega_t)$ is what we observe of the expected returns
- $\xi_{jks}(\omega_t)$ are the unobservable aggregate shocks
- μ_{jit} is unobservable idiosyncratic shock (Type I extreme value)
- $\alpha = \left(\alpha_R, \{\alpha_0(j,k)\}_{j\in J, k\in K}\right)$ are parameters to be estimated.

Conclusion

There are some potentially interesting directions I could take.

- Should I push the first part?
- Or focus on the supply?
- Should I sell it as a project about organic agriculture or more broadly about land use with spatial externalities?

Scientific literature on biodiversity

- Mäder, Paul, et al. "Soil fertility and biodiversity in organic farming." Science 296.5573 (2002): 1694-1697.
- Bengtsson, Janne, Johan Ahnström, and Ann-Christin Weibull "The effects of organic agriculture on biodiversity ad abundance: a meta-analysis." Journal of applied ecology 52.2 (2005):261-269.
- Hole, D. G., et al. "Does organic farming benefit biodiversity?." Biological conservation 122.1 (2005): 113-130.

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