Dynamic discrete choice estimation of transition to organic farming

Industrial Organization 3

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Organic food in the US: demand

- The US Department of Agriculture (USDA)'s label: "Certified to have grown on soil that had no prohibited substances applied for three years prior to harvest", including pesticides, fertilizers and GMOs.

- Sold with a price premium compared to conventional food.
- A market that has grown by 8 to 10% annually since 2000.
- Now 5% of total food sales, more than $47 billion dollars in 2016.

Organic food in the US: supply

- Higher returns, e.g. for soybeans average return in dollars for one acre of soybeans planted:

	Heartland	N. Crescent	N. Great Plains
Conventional	-8.67	-15.06	-47.13
Organic	115.40	183.74	-12.48
Transitional	-162.36	-127.62	-184.81

- 24,506 farms certified in 2016
- High transition rate: A 13% increase compared to 2015!
- But low transition level: 1.2% of farms... and less than 1% of farmland.

Research question

Given these returns, why don't **all** farmers transition to organic farming?

- It appears that farmers also get a price premium.
- But they face more variable yields
- And perhaps more variable market conditions.
- "The organic premium puzzle": not enough return compared to risk?
- Objective of this project: use a dynamic discrete choice model to estimate farmers' return elasticity and risk aversion.

The state variable

- Given each field's state (which includes the crop), farmer i must decide whether to use the organic technology or not.
- 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.

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

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

Two challenges

- So far, quite a standard problem: transition matrices are actually very similar to our first problem set.
- I follow closely Paul T. Scott (2013)'s paper on land use.
- Complicated by two aspects:
- Model: I want to evaluate risk aversion, so I cannot take the expected value of the random variables.
- Scott takes risk neutrality as a given.
- Data: I only have county level data and only for insured crops.
- Scott has: field level data for all fields.

Value function

$$\pi(j, s, t, c, \omega_t) = u(\alpha_0(c, s), \alpha_R, r(c, s); R_c(\omega_t), \epsilon_{cs}(\omega_t), \mu_{sjt})$$

- $R_c(\omega_t)$ is what we observe of the expected returns
- $\epsilon_{cs}(\omega_t)$ are the unobservable aggregate shocks
- μ_{sjt} is unobservable idiosyncratic shock (Type I extreme value)
- $\alpha = \Big(\alpha_R, \{\alpha_0(c, s)\}_{c \in C, s \in S}, r(c, s)\Big)$ are parameters to be estimated: elasticity to returns and to the organic premium, and risk aversion
- I want them to differ by crop c

- Assuming CARA utility function, the certainty equivalent of a random variable writes
$$CE(X) = E(X) - \frac{r}{2}V(X)$$
- I can rewrite the value functions as we did in the course using the certainty equivalent instead:

$$\begin{aligned} V_c(s_{j0}) &= CE_c\left[\sum_{t=1}\beta^t \pi(s_{jt}, \omega_t)|s_{j0}\right] \qquad (1) \\ &= \sum_{t=1}\beta^t \sum_{s_{jt}}\left(\alpha_0(c,s) + \alpha_R R_c(\omega_t) - \frac{r}{2}\left(\mathbb{V}_c(\omega_t) + \mathbb{V}(\epsilon) + \mathbb{V}(\mu)\right)\right. \\ &= \sum_{t=1}\beta^t \sum_{s_{jt}}\left(\alpha_0(c,s) + \alpha_R R_c(\omega_t) - \frac{r}{2}\left(\mathbb{V}_c(\omega_t) + \mathbb{V}(\epsilon) + \frac{\pi^2}{6}\right)\right. \end{aligned}$$

CCP algorithm

First, the choice-specific value functions:

$$v_t(c,s) \equiv \bar{\pi}_t(c,s) + \beta C E_t \bar{V}_{t+1}(k)(s_{t+1}(s_t,k_t)) \tag{2}$$

where $\bar{\pi}_t(c,s) \equiv \pi(c,s,\omega_t,0)$. Then The Hotz-Miller inversion:

$$Pr(c_t = 1|s_t,\theta) = \frac{\exp(v_\theta(c_t = 1, s_t)}{\exp(v_\theta(c_t = 1, s_t) + \exp(v_\theta(c_t = 0, s_t)} \tag{3}$$

While the empirical probability of investing for each state are

$$\hat{P}(c_t = 1|s_t) = \sum_{i=1}^{N}\sum_{t=1}^{T} \frac{\mathbb{1}(c_{it} = 1, x_{it} = x)}{\mathbb{1}(x_{it} = x)}$$

Assumptions about the data

Since I only observe county-level data, I need to make an assumption regarding the mapping of field to county.

$$s_{j,org} = \frac{1}{N_j} \sum_i \mathbb{1}\{s_{jt} = 3\}$$

$$s_{j,trans} = \frac{1}{N_j} \sum_i \mathbb{1}\{s_{jt} \in [1,2]\}$$

$$s_{j,not} = \frac{1}{N_j} \sum_i \mathbb{1}\{s_{jt} = 0\}$$

I need to assume that fields are monotonically transitioned to organic farming *i.e.* when the share of organic corn increases in a county, it means all previous organic fields were grown organic again, and additional fields were converted to organic.

Still: what about transition state?

Conclusion

- Using single-agent discrete choice dynamic model seems relevant to this framework.
- I am making some progress towards understanding how I could implement the tools we have seen in class.
- However, the dataset seems very difficult to work with.
- Find a new dataset?
- Find a different question?