Controlling an Imported Disease in California Lettuce: A Dynamic Structural Econometric Model of Short- vs. Long-Term Decision-Making

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Objectives

- Model farmers' dynamic crop choice and fumigation decisions.
- Estimate the underlying profit structure for long-term growers ("owners") and short-term growers ("renters").
- Evaluate the impact of renting versus owning land on the spread of the disease and on welfare.

Introduction

- $1.4 billion of lettuce grown in California in 2012, much of it in Monterey and Santa Cruz counties.
- *Verticillium dahliae* affects hundreds of plant species, causing Verticillium wilt.
- First detected in lettuce in the Pajaro Valley in California in 1995.
- By 2010, more than 175 fields were infected with Verticillium wilt, amounting to nearly 4,000 acres.
- No control method is available once plants are affected.
- Fungus mainly enters fields carried on spinach seeds.

Control Options:

- Spinach seeds are the vector of disease introduction.
- No control method is available once plants are affected.
- The level of microsclerotia in the soil can be reduced by:
  - Fumigation with methyl bromide
  - Planting broccoli
  - Not planting spinach

Data

- Pesticide Use Reporting Data for Monterey County from 1993 to 2011
- Price, yield, and acreage data from the Monterey County Agricultural Commissioner's Office
- Biological model data from Krishna Subbarao, his colleagues, and their published work

Method

- Dynamic structural econometric model
- Compares decision-making of growers with different time horizons
  - Long-term growers ("owners"): infinite horizon
  - Short-term growers ("renters"): finite horizon
- Generates parameter estimates with direct economic interpretations
- Parameter estimates used to simulate counterfactual scenarios regarding renting and owning

Why Use a Dynamic Model?

- Control options (fumigation with methyl bromide, planting broccoli, not planting spinach) are investments that require long-term planning for future gain
- Investment under uncertainty
  - Irreversible investments
  - There is uncertainty over future rewards from investment
  - Farmers have leeway over timing of investment

$\Rightarrow$ There is an option value to waiting

Results

Actual Welfare

	All	Early	Late
Owner Welfare	100	117.3475	92.7063
	(5.0957)	(19.2088)	(3.4884)
Renter Welfare	25.1943	23.1382	26.8734
	(3.6459)	(1.7604)	(3.9527)

Note: Standard errors in parentheses.

- Average welfare per grower-month is higher in the earlier time period than in the later time period for the long-term growers.
- Average welfare per grower-month is higher for the long-term growers than for the short-term growers over the entire period as well as in both the early and later time periods

Simulations:

- To analyze how differences in grower welfare relate to differences in the data, differences in time horizon, and differences in parameter estimates, we simulate 72 scenarios, each a different combination of: data type, data time period, time horizon, parameter type, and parameter time period.

Simulation Results:

- When using the renter parameters, which reflect differences in incentives faced by owners versus renters, differences in the degree to which the intertemporal externality is internalized by owners versus renters, the severity of Verticillium wilt, the effectiveness of control options, and rental contracts:
  - growers are less likley to engage in control options such as planting broccoli that require incurring current costs for future gain.
- When owners plan over a finite horizon problem rather than an infinite horizon, they no longer plant broccoli and tend to fumigate less.
  - Thus, when growers face a short-term planning horizon rather than a long-term one, they are less likely to engage in control options such as planting broccoli or fumigating with methyl bromide that require incurring current costs for future gain.

Conclusion

- For long-term growers ("owners"):
  - Methyl bromide and broccoli are an effective control options, but require growers to incur costs for future gain.
- For short-term growers ("renters"):
  - Contracts only partially internalize the intertemporal externality
- The long-term decision-making of long-term growers yields higher average per-period PDV welfare and more use of the control options, likely due to: differences in incentives faced by owners versus renters, differences in the degree to which the intertemporal externality is internalized by owners versus renters, the severity of Verticillium wilt, the effectiveness of control options, and rental contracts, and/or a longer planning horizon

References

Rust, J. 1987. "Optimal Replacement of GMC Bus Engines: An Empirical Model of Harold Zurcher." *Econometric: Journal of the Econometric Society* 55:999-1033.

Future Research

In future work, the simulation model will be refined and we will consider different definitions of short- and long-term growers.
We will also connect the model to the source of the Verticillium wilt fungus–spinach seed companies.

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