Economically Optimal Timing of Insect Control in Food Processing Facilities: An Options Approach

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Selected Paper prepared for presentation at the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Annual Meeting, San Francisco, CA, July 26-28

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Introduction

- Fumigating too early in a storage period increases the likelihood that repeat fumigation will be necessary, increasing cost
- Fumigating too late increases potential insect damage, increasing cost
- Motivation: optimal fumigation time can control insects at lowest cost

Why a Real Option?

- This approach values the decision maker's flexibility in choosing to treat insects now, wait until a later date to treat, or not to treat at all.
- Can make the assessment of the costs of failing to control insects more manageable
- Easier to evaluate, interpret, and explain, particularly focused on strategies that reduce chemical use in food processing firms.

Objectives

- Determine the optimal timing to conduct a fumigation with sulfuryl fluoride in a flour mill.
- In order to achieve this objective, the value of a real option to conduct a fumigation is estimated.

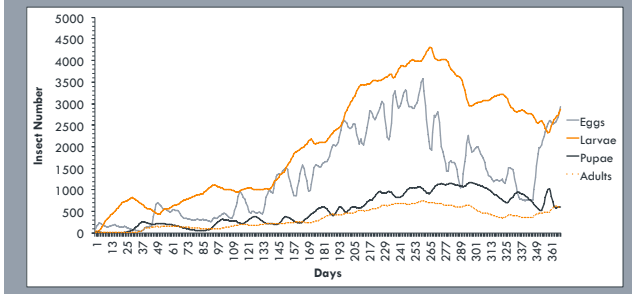

Figure 1. Simulated Insect Population without Treatment

Data

The insect population dynamics are based on a simulation model of the red flour beetle in a flour mill in central Kansas.

Methods

- Using a real option concept: the optimal timing to apply fumigation is when the option value is "in the money" and the time value goes to zero.
- The value of the option to treat:

$$F(V,t) = \max_T ((V_T - TC)*e^{-rT},0)$$

	Time value > 0	Time Value = 0
In the Money: $V_t > TC$	**Wait to treat** until time value goes to 0	Treat **now**
Out of Money: $V_t < TC$	**Wait** to treat	**Never** treat

Mapping a Fumigation Opportunity onto a Call Option

Fumigation Opportunity	Call Option
V: Present value of fumigation ~~(damage reduced)~~	Stock price
TC: Treatment cost	Exercise price
t: Length of time the decision may be deferred ~~(more valuable fumigation later)~~ (length of storage period)	Time to expiration
r: the discount rate	Risk-free rate of return
σ^2: level of uncertainty of the insect damage	Variance of returns on stock
Value of fumigation (*V*) - Fumigation cost (*TC*)	Intrinsic value
Value of option (*F*) - Intrinsic value	Time value

Insect population grows → "out-of-the-money" but positive probability of moving "into the money" → As insect population grows, potential for damage increases → Treat when option has no time value.

Time

Result

- The optimal time to fumigate this particular year was on day 120 of the storage period

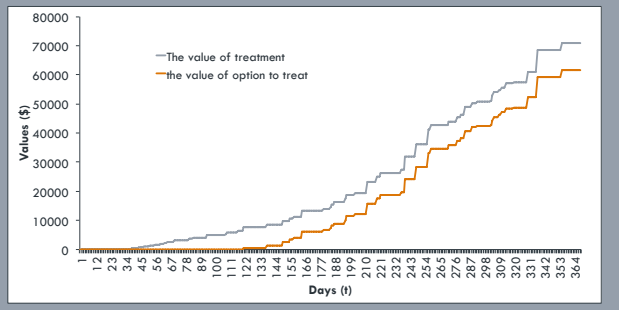

Figure 2. The Value of treatment and The Value of Option to Treat

Conclusion & Discussion

- The value of treatment and value of the option both change with time. When time value goes to zero the option should be exercised.
- A real option approach can help managers evaluate tradeoff between treating now and waiting to treat

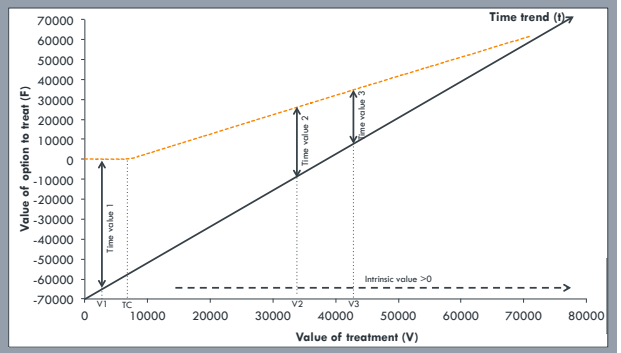

Figure 3. Time Trend for Value of Treatment and Value of Option to Treat