GM Vs. Non-GM: A Survival Analysis of Hybrid Corn Seed in the US

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Poster prepared for presentation at the Agricultural & Applied Economics Association's 2010 AAEA, CAES & WAEA Joint Annual Meeting, Denver, Colorado, July 25-27, 2010.

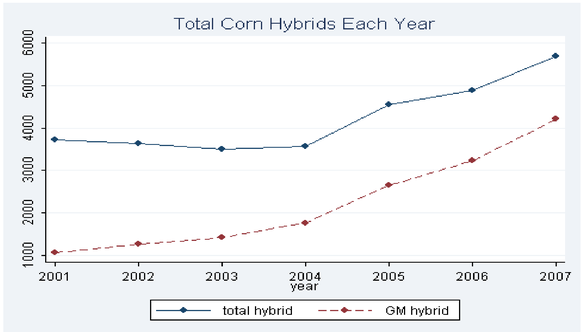
Research Question

With fast adoption of GM corn hybrids and the high turn-over of corn hybrids, two questions are asked:

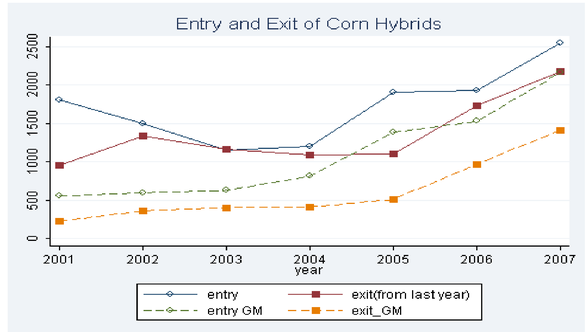
- Does GM corn hybrids behave differently from Non-GM hybrids in terms of survival rate in the market?
- How about other factors, for example, the market structure, affect the survival rate of corn hybrids?

Background

Fast GM Adoption:



High Turn-over:



Empirical Model

Extended Cox Proportional Hazard model:
The hazard function $h(t)$ of a hybrid at time t is defined as

$$h(t) = \lim_{\Delta t \to 0} \frac{Pr(t \leq T < t + \Delta t | T \geq t)}{\Delta t},$$

which can be interpreted as the potential to fail per unit time, given the hybrid has survived up to time t. A Cox Proportional Hazard model with time-varying variables can be written as

$$h(t, X(t)) = h_0(t) \exp\left(\sum_{i=1}^{M_1} \beta_i X_i + \sum_{j=1}^{M_2} \beta_j X_j(t)\right), \quad (1)$$

where $h_0(t)$ is the baseline hazard, X_i are the time independent explanatory variables and $X_j(t)$ are the time dependent variables.

The time-dependent variables are identified by a Goodness of Fit test based on Schoenfeld residuals. Three variables are identified as time dependent: the state level average market share of the seed company, the number of GM hybrids produced by other seed companies, and the number of close substitute hybrids produced by other seed companies.

Define Variables

There are three groups of explanatory variables:
Product characteristics dummies:

- Conventional hybrids(base line);
- Corn Bore(CB) resistant, Root Worm(RW) resistant, Herbicide Tolerance(HT), if any of these traits are embedded in the seed;
- if CB and RW enabled(CB_RW), or CB and HT enabled(CB_HT), or RW and HT enabled (RW_HT);
- if CB, RW, and HT all enabled(CB_RW_HT).

Market Structure:

- Market Share
  The highest average market share across years among all the locate market(state)
- Vertical Integration: If integrated by a bio-trait company.
- Number of Competing Products
  - Number of "similar" hybrids introduced by its own producer *or* by other producers during the life time of the hybrid. (N_own and N_others)
  - the number of all the GM hybrids produced by other seed companies (N_GM_others).

Location and Year Dummies:

- The latitude and longitude weighted by projected acres;
- The year dummies are the entry years.

Data and Result

Data:
Our data come from a stratified sample of U.S. corn farmers surveyed annually from 2000 to 2007. The survey provides farm-level information on corn seed purchases, corn acreage, hybrid types, seed brands, etc. To avoid left-censoring problem we focus on seeds entering the market in and after 2002. The first two years data are used only to identify seed entry since 2002. We also dropped those "new" hybrids showing up in 2007, as we would like to have at least two years observations of how each "new" seed performs in the market. Therefore, our final data set contains 7,699 hybrids, of which 2736 are conventional hybrids, from 46 states that entered the market from 2002 to 2006.

Result:

Dependent Var: Log(h)	Model A		Model B		Model C	
	Coef.	Z-stat.	Coef.	Z-stat.	Coef.	Z-stat.
	Biotech Characteristics					
CB	-0.059	-1.43	-0.002	-0.05	-0.799	-14.4
RW	0.167	2.22	0.235	3.07	-1.172	-13.4
HT	-0.159	-4.24	-0.152	-3.92	-0.531	-10.5
CB_RW	-0.285	-2.19	-0.362	-2.74	0.663	4.83
CB_HT	-0.108	-1.69	-0.116	-1.8	0.769	10.48
RW_HT	-0.179	-1.39	-0.202	-1.56	0.445	3.29
CB_RW_HT	-0.801	-4.97	-0.885	-5.41	0.996	5.54
	Market Structure					
Market share					-2.141	-8.3
Market share*log(t)					1.771	7.23
N_others					-0.003	-29.7
N_others*log(t)					0.001	12.81
N_GM_others					0.039	6.75
N_GM_others*log(t)					-0.01	-2.11
N_own					-0.003	-1.06
Vertically integrated					-0.592	-5.84
	Other Covariates					
Weighted latitude			-0.158	-1.73	-0.198	-2.2
Weighted latitude squared			0.002	1.91	0.003	2.26
Weighted longitude			-0.24	-7.92	-0.201	-6.25
Weighted longitude squared			0.001	7.5	0.001	6.01
Year 2003			-0.113	-2.55	-0.584	-12.8
Year 2004			-0.108	-2.32	-0.737	-15.4
Year 2005			-0.032	-0.75	-0.52	-11.9
Year 2006			-0.035	-0.72	-0.871	-18.0
Number of observations	7699		7699		7699	
Likelihood Ratio	-43414.9		-43366.3		-42000.0	

Summary

We find that the characteristics of products, the embedded GM traits in our case, contributes significantly to the survival of corn seed hybrid. We also find that the market share of the seed company helps reduce the hazard with a decreasing effect over time. We find strong spill-over effect among similar products, and strong competition effect among total GM hybrids and between conventional hybrids and GM hybrids. We do not find strong evidence of cannibalization effect. We also find that hybrids designed for the center region generally survive longer, and so do the newly introduced hybrids.