Government Policy Implications of Crop Rotational Effects of Biotechnology

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Background

Commercially grown genetically modified organism (GMO) corn and soybean varieties were first introduced in the United States in 1996. Since then, farmers have rapidly adopted herbicide tolerance (HT), insect resistance (Bt), and stacked (both traits) GMO corn and soybean varieties.

Many studies have considered a variety of broad-based implications of using GMO crop varieties (e.g. Van der Sluis, Diersen, and Dobbs 2002). Recent studies suggest that GMO adoption rates may be linked to changes in agricultural producer production practices (e.g., Fausti et al. 2012; Scandizzo and Savastano 2010).

The development of corn and soybean biofuel conversion technology as an alternative to fossil-based fuels allowed U.S. energy policy to implement mandates for biofuels. The policy goal is to have biofuels become an important source of energy for the U.S. economy. The two primary legislative mandates are the 2005 Energy Policy Act and the Energy Independence and Security Act of 2007. The current legislation sets minimum annual consumption levels in four broad-based biofuel categories: cellulosic, biomass-based diesel, undifferentiated advanced, and renewable energy.

While there is no explicit mandate for corn-based ethanol, corn has dominated as a source for biofuel production because of its cost-advantage relative to alternative biofuels. Further, U.S. biofuel policies have had far-reaching consequences. In particular, recent studies suggest that corn demand driven by increased corn-based ethanol production has influenced producer crop rotation patterns in the U.S. (Kurkalova, Randall, and Secchi 2010; Marshall 2011).

Objectives

Our objective is to investigate the effect of the linkage between the use of major genetically enhanced crops and bioenergy production from these crops on cereal and oilseed crop rotation patterns in the U.S. corn-belt region.

Fig. 1. The Corn Belt region

Hypotheses

We hypothesize that the interaction between the introduction of GMO crop technology and the boom in bioenergy production has altered cropping patterns in the Northern Corn Belt.

We investigated changes in producer crop rotation patterns at the state level using the ratio of corn to soybean acres as a proxy for traditional cropping patterns prior to widespread GMO technology adoption and the linkage between energy and commodity markets due to corn base ethanol production.

Fig. 2. Bioethanol production at the Valero plant in Aurora, SD

Methods

Our approach relies on the development of a comparative advantage framework that allows producers to switch crop rotation patterns as GMO crop prices change relative to non-GMO crop prices. The relative price change is due to changes in U.S. government energy policy.

Our empirical analysis is based on a pooled cross-sectional/time series model of cropping patterns, based on annual data collected in Corn Belt states between 2000 and 2012.

A Mixed Effects procedure employing a random intercept model with time-varying predictors (X_{it}, T_t) was selected to analyze the data. The specific functional form is:

$$CSR_{it} = \mu + \beta X_{it} + \delta\, T_t + \varphi X_i T_t + \alpha_i + \varepsilon_{it}\,,$$

where:

- CRS = state-level corn/soybean total planted acre ratio
- $i = 1$ *to* 11, *and* $t = 1$ *to* 13, i denotes state, t denotes time
- μ denotes a fixed intercept,
- α_i and ε_{it} represent the random effect components, and
- X_{it} and T_t denote the fixed effect components

We conducted a series of likelihood ratio tests to determine the exact specification of the model. Regression diagnostic tests failed to detect serial correlation or heteroscedasticity.

Data

We used secondary state-level data on acres of crop acres planted, GMO coverage, and crop prices of eleven northern corn belt states for each year between 2000 and 2012. A total of 143 observations were used in the analysis.

Analysis

The dependent variable (CSR) is the ratio of total corn acres to total soybean acres by state. Explanatory variables include the ratio of annual corn to soybean prices, priceratio; an ethanol policy dummy variable, so that Reg=1 for years from 2005 to 2012; the state-level percentage of corn acres planted with GMO seed, GECorn; a time trend variable constructed as the natural logarithm of time, lntime; an interaction terms of GMO corn acres planted and the time trend variable; and another interaction term between a dummy variable distinguishing between individual states with zero and non-zero slope coefficients in regressing CSR on time.

Results

The statistical analysis suggest that an increase in the corn/bean price ratio, the adoption of GMO technology, and the passage of the biofuels acts of 2005 and 2007 have all contributed to changing the traditional cropping pattern in favor of producing more corn acres relative to soybeans. Interaction terms suggest that the impact of genetically modified crop usage on crop rotations patterns diminished over time as states reached very high adoption rates, and the states of Ohio, Kansas, and Missouri experienced little change in corn/bean planted acre ratio relative to the other eight states included in the study.

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
Intercept	ID	0.1975	0.08827	2.24	0.0126
Residual	ID	0.01279	0.001607	7.95	<.0001

Fit Statistics

-2 Res Log Likelihood	-122.9
AIC (smaller is better)	-118.9
AICC (smaller is better)	-118.8
BIC (smaller is better)	-118.1

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
priceratio	2.5102	0.2803	126	8.96	<.0001
REG	0.2257	0.04666	126	4.84	<.0001
GECorn	0.003849	0.001996	126	1.93	0.0561
lntime	-0.04555	0.04420	126	-1.03	0.3047
GECorn*lntime	-0.00171	0.000700	126	-2.45	0.0156
lntime*iddum	0.09953	0.02859	126	3.48	0.0007

Conclusions

Our findings indicate that an increase in the corn/bean price ratio, the adoption of GMO technology, and the passage of the biofuels acts of 2005 and 2007 each changed traditional cropping patterns such that corn acres planted increased relative to those of soybeans. The research further indicates that GMO effect has diminished over time as states reach very high adoption rates. Finally three of the eight Corn Belt states studied experienced little change in the corn to soybean acres planted.

References

Fausti, S.W., T. McDonald, J. Lundgren, J. Li, A. Keating, and M. Catangui. "Insecticide Use and Crop Selection in Regions with High GMO Adoption Rates." Renewable Agriculture and Food Systems, Vol. 27, No. 4, 2012: pp. 295-304.

Kurkalova, L.A., S. M. Randall, and S. Secchi. "Energy Price Changes, Cropping Patterns, and Energy Use in Agriculture: Empirical Assessment." Working Paper, Department of Economics and Finance and Energy and Environmental Systems Program North Carolina A&T State University: 09/07/2012.

Marshall, K.K. "Essays on Ethanol-Driven Corn Demand and Crop Choice." Ph.D. Dissertation, Oregon State University, June 2, 2011.

SAS Institute Inc. 2011. SAS/STAT® 9.3 User's Guide (Chapter 6). Cary, NC: SAS Institute Inc.

Scandizzo, P.L., and Savastano, S. "The Adoption and Diffusion of GM Crops in United States: A Real Option Approach." Ag Bio Forum, Vol. 13, No. 2, 2010: pp. 142-157.

Van der Sluis, E., M.A. Diersen, and T.L. Dobbs. "Agricultural Biotechnology: Farm Level, Market, and Policy Considerations." Journal of Agribusiness 20, 1 (Spring 2002): 51 66.

For further information

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