Valuing the Option to switch to Organic Farming: an Application to U.S. Corn and Soybeans

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Abstract

Based on option value theory, we develop a theoretical model to assess the dollar compensation required for the conversion to organic farming. Our empirical model is a switching regression model with two regimes and we use county level data on organic and conventional corn and soybean production in the U.S. for the application. Assuming an interest rate of 10 percent, a conventional corn-soybean grower would need to receive a one-time payment of $315 per acre to compensate for the conversion cost and an additional $1,088 per acre to cover the long run higher production and market risks. The sum of these two values equals an annual payment of $228 per acre for a 10 year contact. The results are discussed in the context of the recently introduced Conservation Security Program, which will make direct payments to US farmers for organic practices.

Keywords: option theory, organic farming, direct payments, switching regression, Conservation Security Program

JEL classification: D81, Q18.

1. Introduction

Organic farming is one of the fastest growing segments of U.S. agriculture. Certified organic farmland for corn, soybeans and livestock doubled between 1992 and 1997, and doubled again between 1997 and 2001. In total, there were 2.3 million acres of cropland and pasture dedicated to organic production in 2001 (Greene and Kremen, 2003). Irrespective of the high growth rates, organic production remains a very small fraction of U.S. agriculture, 0.3 percent of all farmland is certified organic and organic food sales represent 1.3 percent of total food expenditures (MacInnis, 2004).

The realisation that agriculture has a major impact on the environment has led to a change in policy to make organic production more attractive to farmers. The 2002 U.S. Farm Bill introduced policies that could substantially increase government support for organic agriculture. Notably, the federal Conservation Security Program (CSP) will make direct payments to farmers for preexisting and ongoing conservation work. This is the first time that a farm bill has contained provision for "green" payments. Under the CSP, many growing practices that are standard on organic farms will qualify for payments. In contrast, existing federal programs only share the cost of installing new conservation projects. With the announcement of the CSP it becomes relevant to ask the question: what level of direct payments will induce a conversion to organic farming?

At present, there exists little theoretical work or empirical evidence on the dollar compensation that would be needed to induce U.S. farmers to voluntarily adopt organic practices. The literature has focused on the use of discrete choice methods to analyze farmers' decisions whether or not to adopt organic farming. While these methods yield probabilities of adoption, the resulting estimates cannot be readily converted into dollar compensation levels (Klonsky and Smith, 2002; Kurkalova et al., 2003). For a discrete choice model to provide this information, direct subsidies have to be included as an independent variable (e.g., Fairweather and Campbell, 1996; Lohr and Salomonson, 2000; Pietola and Oude Lansink, 2001). However, this is not an option in the context of the CSP, because direct payments are yet to be introduced. Thus, we take a different modelling approach.

Our theoretical model starts from the observation that many non-organic farmers perceive organic farming as more risky than conventional farming (Padel and Lampkin, 1994). Previous survey research has shown that farmers perceive the uncertainty of the conversion to organic as a major obstacle (Padel, 2001). Legally, a farm in transition from conventional to organic must keep rigorous records for three years before being fully certified. The physical transition cost may be incurred for several more years, including penalties in yield or costs due to agro-ecosystems adjustments and management inefficiencies while new practices are learnt. Key financial constraints are the lack of access to premium prices until conversion is complete, conversion-related investments and disinvestments, and information gathering costs for production and marketing (Lohr, 2001). In the presence of these transition costs and uncertainty about the future development of earnings, a risk neutral farmer is not indifferent between organic and conventional if current returns per acre are similar for both practices.

Our theoretical model of a farmer's decision to convert to organic farming under uncertainty is based on option value theory (MacDonald and Siegel, 1986; Pfann, 2001; Wossink and Gardebroek, 2005). The difference between the option value approach and the traditional net present value approach is that a farmer switches to organic farming when the net present value of the difference in expected future cash flows from conventional and organic farming exceeds the costs of transition plus an option value. The option value is the discounted value of the dollar compensation required because of the additional uncertainty. The theoretical model depicts two effects of a change in policy in favour of organic practices. The direct effect of such policies is to decrease the option value. In addition, the possibility of future changes to the policy may indirectly increase or decrease the option value, depending on farmers' expectations.

Based on the option approach, and following Spiller and Huang (1986), our empirical model for conversion from conventional to organic farming is a switching regression model with two regimes. We implement the empirical model for corn and soybeans using a data set summarizing organic agriculture from the Organic Farming Research Foundation (OFRF). OFRF periodically conducts a national survey of organic farmers, yielding the most complete set of information available on organic farming in the United States.

We proceed as follows. The next section presents the theoretical model, followed by a discussion of the Conservation Security Program, the empirical model and a description of the data. We conclude with results, conclusions and policy implications.

2. Theoretical model

2.1 The option value approach

An important pre-condition for widespread adoption of organic farming, or any new technology, is its profitability for farmers. Also in organic agriculture a truism is that the later adopters are more often motivated by profitability (Lohr, 2000, p. 136). Thus, our theoretical model assumes profit maximization.

At present time t = 0 a representative, risk-neutral farmer values the expected lifetime returns from conventional farming as C_0. In the meantime he scans the expected returns from organic farming. Let O_0 denote the present value of the expected lifetime earnings of organic farming for the representative farmer at time t = 0. To obtain O_0 the farmer must incur fixed costs that become sunk upon transition. These sunk costs include the record keeping, physical transition, management, financial and information costs discussed above. In the presence of fixed transition costs and uncertainty about the future development of the expected stream of earnings differences the farmer is not indifferent if $C_0 = O_0$.

Let R_t denote the differential between the discounted expected cash flows for a farmer who gives up conventional farming for organic farming at time t, and let T denote the fixed transition costs for the representative farmer. Under a conventional NPV calculation, the farmer will make the switch if $R_t - T \geq 0$. The value of R_t, however, becomes increasingly uncertain the further t lies in the future because of production and market uncertainty. Thus, R is assumed to follow a geometric Brownian motion with drift:

$$dR = \mu R dt + \sigma R dz \quad (1)$$

where μ is the expected growth rate of the stream of value differences between the discounted expected cash flows; σ is the standard deviation; and *dz* is the random increment of a standard Wiener process such that $Edz = 0$, $Edz^2 = dt$.

The geometric Brownian motion implies that the present value of switching from conventional to organic farming may be different if the transition is postponed. Equation (1) implies that future values of the investment are log-normally distributed with expected value $E_0[R_t] = R_0 \exp(\mu t)$, where E_0 denotes the expectation at time *0.* Assuming that the investment is infinitely lived, the expected value, $F[R]$, of the differential *R* is (Macdonald and Siegel, 1986):

$$F[R] = \max\left[E(R_t - T)e^{-rt} \middle| \Omega_0 \right] \tag{2}$$

subject to equation (1), where *t* is the time of investment, *r* is the discount rate and Ω_0 is the information available to the farmer at $t = 0$.

The total return for investing at the beginning of the period is *rF*. The value of postponing the investment decision is equal to the expected increase in *F* during this period. The first order condition for this problem is $rFdt = E\,dF|\Omega_t$. Using Ito's lemma to obtain the total differential for dF, the first order condition can be rewritten as $\frac{1}{2}\sigma^2 R^2 F''(R) + \mu R F'(R) - rF = 0$. The analytical solution is widely available in the literature (e.g. MacDonald and Siegel, 1986) and yields:

$$R^* = \alpha T \quad \text{where} \quad \alpha = \beta/(\beta - 1) \tag{3}$$

with $\beta = \frac{1}{2} - \mu/\sigma^2 + \sqrt{(\mu/\sigma^2 - \frac{1}{2})^2 + 2r/\sigma^2}$. Since $\beta > 1$, $\alpha > 1$ and hence $R^* > T$ [1]. Thus, in the presence of irreversibility and uncertainty the NPV principle that equates *R* with *T* is no longer applicable. Uncertainty brings about a positive wedge between the trigger value *R** and the traditional NPV hurdle *R*. This wedge with size $(\alpha - 1)T$ is the value of the option to postpone the decision to convert to organic farming because of the production and market risk reflected in σ. The wedge can be substantial even for small levels of uncertainty about future returns.

2.2 Sensitivity of the conversion trigger value to changes in agricultural policy

Since 2001, there have been three major policy changes that differently affect organic farmers. The US Department of Agriculture (USDA) has made organic farmers eligible for partially subsidised crop insurance, it has introduced conversion subsidies, and it has introduced a system of direct payments for existing conservation practices (many of which are standard for organic growers). Each of these changes should reduce the trigger value, R^*, at which the conventional farmer chooses to switch to organic. Conversion subsidies directly decrease the cost of conversion; in equation (3) a decrease in *T* decreases R^*. Similarly, the net present value of a series of direct payments can be subtracted from the transition costs, also decreasing R^*. The availability of crop insurance decreases R^* by reducing the uncertainty, associated with the difference in the stream of returns from organic and conventional farming.

While the direct effects of introducing conversion subsidies, payments and crop insurance is to reduce the value of postponing the conversion decision, these policies also introduce a new dimension of uncertainty if farmers are unsure about the life of the programs and other future policy changes. This policy uncertainty may, in turn, affect option values. While there are many possible sources of policy uncertainty – see Gardner (2001) for a useful overview – we will focus on a single fairly general case.

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[1] If $r \leq \mu$, the value of the investment opportunity will be infinity and the farmer will never exercise the option to convert .

Suppose that farmers believe that at some unknown future date the difference in returns from organic and conventional farming may take a discrete jump upward or downward because of an additional policy change affecting organic farming. Then equation (1) can be rewritten as a mixed Wiener-Poisson process:

$$dR = \mu R dt + \sigma R dz + R dq \tag{4}$$

where the Poisson event is uncorrelated with R and defined as :

$$dq = \begin{cases} \theta \text{ with prob. } \lambda dt \\ 0 \text{ with prob. } (1 - \lambda) dt \end{cases}$$

Equation (4) implies that at each point in time there is positive probability λ that returns will change by θ percent, with the direction of the change depending on the sign of θ. In this case, the expected trend reflects the policy uncertainty: $E(dR)/R = \mu + \lambda\theta$. In the presence of this policy uncertainty, the first order condition for the value of the investment opportunity, $rFdt = E\,dF|\Omega_t$, can be written as $\frac{1}{2}\sigma^2 R^2 F''(R) + \mu R F'(R) - (r+\lambda)F(R) + \lambda F[(1+\theta)R] = 0$. The solution is again of the form $R(\lambda)^* = \alpha(\lambda)T$ with $\alpha(\lambda) = (\beta(\lambda)/(\beta(\lambda)-1))$ where $\beta(\lambda) = f(\lambda, \theta, \mu, \sigma, r)$ is implicitly defined by the equation: $\frac{1}{2}\sigma^2 \beta(\lambda)[\beta(\lambda)-1] + \mu\beta(\lambda) - (r+\lambda) + \lambda(1+\theta)^{\beta(\lambda)} = 0$.

The effect of policy uncertainty on the conversion trigger value depends on whether the policy change is expected to increase or decrease the relative returns to organic farming. First, consider the case where the policy change increases the relative returns to organic. For example, farmers might believe there is a positive probability that the size of the conversion subsidies will increase in the future (θ>0). A positive value of θ has two effects on R^*; it increases the expected growth rate of R which increases $F(R)$ and it increases the variance of R which also increases $F(R)$. It follows that $\beta(\lambda) < \beta$, $\alpha(\lambda) > \alpha$ and thus $R^*(\lambda) > R^*$. A positive probability of a change in agricultural policy that increases the relative returns of organic farming increases the value of postponing the conversion decision, and this increases the critical value.

Now suppose farmers anticipate a policy change that would decrease the relative returns to organic farming. For example, farmers might suspect that USDA may terminate its conversion subsidies at some point in the future (θ<0). A negative value of θ decreases the expected growth rate of R and increases its variance. The net effect is to reduce $F(R)$ (Dixit and Pindyck, 1994; p. 167-173). In this case $\beta(\lambda) > \beta$, $\alpha(\lambda) < \alpha$ and thus $R^*(\lambda) < R^*$. The possibility that current policies (which are favourable to organic farming) will be terminated in the future decreases the incentive for a farmer to postpone the conversion decision, decreasing the conversion trigger value.

2.3 Discussion

Four comments about the theoretical model are appropriate. First, it is important to emphasize that the results depend only on the properties of *dz* and that the Wiener process (or Brownian motion) can be generalized to a broad class of continuous-time stochastic processes (Merton, 1990). The geometric Brownian motion serves as a convenient example because it has an analytical solution. Alternatively, we could obtain similar results by assuming that R follows a mean reverting process (Odening et al., 2005).

Second, as demonstrated by MacDonald and Siegel, incorporating risk aversion considerations in the model does not affect the solutions for R^* and $R^*(\lambda)$. This follows from the implicit assumption in the option approach of an exponential utility function in combination with the Brownian motion-Poisson jump process.

Third, following the theoretical model, farmers' decision to switch to organic farming will not be completely due to differences in returns and transition costs. We expect farmers to react to production and market uncertainty and thus to find proof of option values that reflect the value of waiting to switch.

Fourth, he interest in the application to the transition to organic farming lies with the multiplication factors α and $\alpha(\lambda)$ that distinguish the NPV trigger, R, from its real-option counterparts R^* and $R^*(\lambda)$. In addition, a comparison of R^* and $R^*(\lambda)$ enables an assessment of the development in the option value over time. We expect that a change in agricultural policy in favour of organic farming leads to a distinct decrease in the option value, although it may also increase policy uncertainty.

3. Application

3.1 The 2002 Farm Bill and Conservation Security Program

The Conservation Security Program is part of a dramatic change in U.S. farm policy toward organic growers. Traditionally, intervention by the USDA to stimulate organic agriculture focused primarily on market facilitation, such as establishing federal standards and labels (Lohr, 2001). Prior to 2001, organic growers were eligible for less financial support than their conventional counterparts. While organic growers received compensation from standard commodity support programs, federal crop insurance policies would generally not compensate them for losses because organic farming prevented the use of some of the (chemical) techniques expected under the official definition of “good farming practices”. This changed under the 2000 Agricultural Risk Protection Act and crop insurance for many organic crops became available by May 2001. The 2002 Farm Bill introduced two additional major policy changes. It funded “agricultural management assistance” which can be used in selected states to pay for 75% of the cost of conversion to organic agriculture, up to $50,000 per producer. It also created the Conservation Security Program, which will provide direct payments for ongoing environmental stewardship on agricultural land.

The duration and amount of CSP payments depend on the extent of conservation work performed on the farm and the acres enrolled. To apply for the program, farmers must submit detailed records on farming practices for at least the previous two years. A qualified farm will be placed into one of three tiers according to the extent of conservation activity on the farm. Tier I farmers must have addressed soil and water quality to satisfy the Field Office Technical Guide (FOTG) standards on part of the farm prior to enrolment. Tier II farmers must have addressed soil and water quality on the entire farm, and agree to address one additional resource concern by the end of the contract period. Tier III farmers must have satisfied FOTG standards on all resource issues for the entire farm, prior to enrolment (US Department of Agriculture, 2004a, b).

Within each tier, the actual payment is equal to the number of acres enrolled multiplied by a base payment rate, plus “enhancement payments” for exceptional conservation effort beyond the required levels. Depending on the tier, the base payment is 5-15 percent of the average national per acre rental rate for a specific use or an appropriate adjusted regional rental rate. The second portion of the CSP payment is the average county cost of adopting or maintaining practices for the crop year.

The total annual payment per farm and the length of payments are capped in each tier according to the following scheme: (Tier I) up to $20,000 for five years, (Tier II) up to $35,000 for 5 to 10 years, and (Tier III) up to $45,000 for 5 to 10 years. Contracts for Tier II and II can be renewed; for Tier I renewal requires broadening the scope of practices. Because of funding limits, the program is operated on the basis of individual watersheds, and rotated around the country with signups for different areas each year (US Department of Agriculture, 2004c). CSP program officials speculate that within 8 years, every farmer in the U.S. will have had an opportunity to enrol.

The most obvious benefit of the CSP for organic farmers is the reduction of individual farm income risk. By virtue of their certification, organic farmers automatically satisfy a subset of the relevant FOTG standards. This suggests the average organic farm is closer to enrolment in the program than the average conventional farm and certified and in-transition organic farmers are likely to qualify for Tier 3 payments (Lohr, 2001). Payment will be specifically tied to actual farming practices and their relative impact on environmental quality and resource protection. The farmer will receive 15 percent of the base payment plus 75 percent (90 percent for beginning farmers) of the average practice cost. Though the maximum payment is $45,000 per farmer per year, Tier 3 total base payment may not exceed 30 percent of the tier limit, or $13,000.

3.2 Empirical model

Recall that R is the differential between the discounted expected cash flows of conventional farming and organic farming and so: $R = (O\text{-}C)/r$. This differential is attributed to unobservable transition costs and an option value. From the theoretical model follows for the individual observation i:

$$R_i = e^a T_i \qquad \text{if option value} \tag{5}$$

$$R_i = T_i \qquad \text{if no option value} \tag{6}$$

with $a > 0$. Following Spiller and Huang (1986) we specify transition cost T_i as a random variable with constant mean, T, that is

$$T_i = Te^{\nu_i} \tag{7}$$

where ν_i is normally distributed with zero mean and constant variance σ_ν^2. Substituting (7) into (5) and (6) and taking natural logs gives:

$$\ln R_i = a + \ln T + \nu_i \qquad \text{if option value} \tag{8}$$

$$\ln R_i = \ln T + \nu_i \qquad \text{if no option value} \tag{9}$$

where $a > 0$. Equation (8) and (9) may be expressed as a switching regression system with a probability ℓ of observing an option value and a probability $1 - \ell$ of observing no option value. When returns follow a random walk as assumed in the analysis, the rational expectations forecast for the returns is today's returns. The definition of R_t in the empirical model is based on this principle:

$$\ln\left(\frac{O_{it} - C_{it}}{r_t}\right) = a + \ln T + \nu_{it}, \text{ with probability } l, \tag{10}$$

$$\ln\left(\frac{O_{it} - C_{it}}{r_t}\right) = \ln T + \nu_{it}, \text{ with probability } 1\text{-}l, \tag{11}$$

where O_{it} is the observed net earnings in organic farming for observation i at time t; C_{it} is observed net earnings in conventional farming for observation i at time t; r_t is the interest rate at time t; ν_{it} is a normally distributed i.i.d. variable; and a and T are parameters to be estimated. If equation (11) prevails, production and market risks are of no significance to organic growers. In the case of equation (10), there is a positive option value. Using the estimates of T and a, option values can be calculated as $(e^a - 1)T$.

Equations (10) and (11) estimate a constant option value attributed to production and market uncertainty for the entire estimation period. To allow for year-specific changes in the option value we replace (5) by $R_i = e^{a + D_i\gamma} T_i$, where $D_i = 1$ if the observation relates to the specific year, and replace (10) with:

$$\ln\left(\frac{O_{it} - C_{it}}{r_t}\right) = a + D_{it}\gamma + \ln T + \nu_{it}. \tag{12}$$

To estimate the probability l of the switching regime model, parameters were chosen in order to maximize the log of the likelihood function:

$$L = \prod_{i=1}^{N} [l_1 f_i^1 + (1 - l_1) f_i^2], \tag{13}$$

where N is the total number of observations and f_i^1 and f_i^2 denote the density functions of

$$f_i^1 = \frac{1}{\sigma_v} \phi\left(\frac{Z_1}{\sigma_v}\right), \tag{14}$$

$$f_i^2 = \frac{1}{\sigma_v} \phi\left(\frac{Z_2}{\sigma_v}\right), \tag{15}$$

where: $Z_1 = \ln\left(\frac{(O_{it} - C_{it})}{r_t}\right) - a - D_{it}\gamma - \ln T$; $Z_2 = \ln\left(\frac{(O_{it} - C_{it})}{r_t}\right) - \ln T$; and ϕ is the density function of the standard normal variable.

The switching regime model was first estimated without a time dummy. A second model specification includes a time dummy to distinguish the year 2001. The estimate for γ allows testing for the extent to which the option value in 2001 differs from that in previous years; due to the introduction of organic crop insurance (in May 2001), for example.

3.3 Data

We employed data on individual organic farms from the OFRF (see http://www.ofrf.org), which collects the data through a periodic national survey. OFRF provided us with survey results for two years, 1997 and 2001. Over 80 organically produced crops are included in the data. We implement the empirical model for corn and soybeans. In 2001, these two crops accounted for about 10 % of all certified organic cropland in the U.S., or 21.5 % if hay & silage are excluded (Greene and Kremen, 2003).

Each individual farm-year observation consists of a set of economic variables and a spatial identifier. The economic variables include acreage, production, price, and yield. Similar economic information for conventional production on the same farm set is not available. The spatial identifier includes the state and zip code of each farm. The economic variables along with the spatial identifier allow us to assess county-level prices and yields of organic varieties of each crop. As a proxy for conventional returns, we use county-level data on price and yield reported by the USDA National Agricultural Statistics Service. In addition, we assume that there is no difference between production costs for conventional and organic corn and soybeans at the county level. We are well aware of the work by Delate and others (e.g., Delate et al., 2003; Delate and Cambardella, 2004) who find that the higher seed, fieldwork and production costs are outweighed by the greater pesticide and fertilizer costs incurred for conventional varieties. We prefer a conservative stance and assume equal production costs for conventional and organic corn and soybeans.

For soybeans, we have 247 farm level observations that stretch across 142 counties in 16 states. For corn we have 100 observations from 72 different counties across 14 states. Prices and returns are reported in 2001 dollars. Table 1 illustrates that price premiums for organic corn and soybeans more than compensate for lower average yields. Table 2 presents the summary statistics of the data as used in the empirical work. After omitting the counties with only one observation for organic production, we were left with observations for 45 counties.

Table 1. All observations

Crop-Year		Yield (bu/acre) Organic	Yield (bu/acre) Conventional	Price ($/bu) Organic	Price ($/bu) conventional	Gross Returns ($/acre) Organic	Gross Returns ($/acre) conventional	Organic Acres/Farm	# Organic Observations
Corn	1997	96.4 (27.4)	126.6 (17.2)	4.6 (0.8)	2.6 (0.2)	439.2 (138.0)	331.0 (46.5)	63.0 (47.3)	51
	2001	91.4 (32.2)	137.1 (18.9)	3.6 (0.5)	2.0 (0.1)	332.4 (120.5)	268.6 (35.0)	59.0 (58.8)	49
Soybeans	1997	30.7 (9.9)	41.5 (5.7)	17.6 (3.7)	7.1 (0.2)	538.1 (221.0)	293.0 (40.7)	89.0 (111.6)	144
	2001	27.4 (11.0)	38.7 (7.6)	12.3 (2.6)	5.3 (0.00)	339.7 (155.2)	203.7 (39.8)	76.0 (74.3)	103

*Prices and returns are reported in $2001. Standard deviations are in brackets. The 2001 Soybean price is based on the loan rate.

Table 2. Summary statistics as used in the estimation, county level averages

Crop-Year		Yield (bu/acre) Organic	Yield (bu/acre) Conventional	Price ($/bu) Organic	Price ($/bu) conventional	Gross Returns ($/acre) Organic	Gross Returns ($/acre) conventional	# Counties
Corn	1997	87.4 (11.9)	115.0 (13.9)	4.6 (0.0)	2.5 (0.1)	402.1 (56.5)	287.8 (42.8)	3
	2001	104.9 (11.9)	143.9 (13.0)	3.5 (0.3)	1.9 (0.0)	363.1 (63.7)	277.4 (26.5)	5
Soybeans	1997	31.7 (9.0)	41.0 (5.1)	18.1 (2.3)	7.1 (0.1)	572.5 (187.8)	289.2 (36.9)	23
	2001	29.4 (6.4)	38.8 (4.7)	12.9 (1.8)	5.3 (0.00)	379.9 (96.3)	204.2 (24.7)	14

*Prices and returns are reported in $2001. Standard deviations are in brackets. The 2001 Soybean price is based on the loan rate.

4. Results

We present results from the switching regime model for the combined corn-soybean data and for each crop individually. Tables 3a/b and 4a/b summarize the results from using these data to estimate the likelihood functions shown in equations 14 and 15. The econometric model cannot separately identify the interest rate and the per/acre transition cost (T), as can be seen from equations 10 and 11. Therefore, we estimate the model for interest rates ranging from 0.05 to 0.15.[2] The tables also show the per-acre option value implied by the parameter estimates.

The estimate for the probability ℓ provides evidence of option values (Table 3a). The 95% confidence interval for ℓ is 0.90 ± 0.06 and does not include 0, which provides evidence that the regime with an option value was dominant. The estimate for the conversion costs, *T*, ranges from $211.09 to $631.49 per acre for the pooled data. Depending on the assumed interest rate (0.05-0.15),

[2] The annual average return on 6-month T-bills between 1997 and 2001 was approximately 5%, and the 75th quartile of returns on farm assets was 6.5% (Hopkins and Morehart, 2000). However, the relevant interest rate must also incorporate the non-diversifiable risk associated with organic farming. We expect this risk is substantial, given that price premiums in organic markets may depend on supply and demand factors that are largely uncorrelated with conventional markets. This is also an explanation for why organic farmers were ineligible to purchase government crop insurance before 2001. We use an interest rate of 10% as our baseline.

Table 3a: Parameter estimates Option Value Model for pooled corn and soybeans data

Parameter	Symbol	Discount Rate				
		r = 0.05	r = 0.075	r = 0.1	r = 0.125	r = 0.15
Option Value Parameter	a	1.87*** (0.33)	1.86*** (0.33)	1.87*** (0.33)	1.87*** (0.33)	1.87*** (0.33)
Mean Conversion Cost Per Acre	T	631.49** (220.75)	423.29** (147.85)	316.34** (110.55)	253.05** (88.43)	211.09** (73.76)
LLF Probability	ℓ	0.90 (0.06)	0.90 (0.06)	0.90 (0.06)	0.90 (0.06)	0.90 (0.06)
Standard deviation of ν error term	σ_v	0.54*** (0.07)	0.54*** (0.07)	0.54*** (0.07)	0.54*** (0.07)	0.54*** (0.07)
Implied Option Value ($/acre)		3,462	2,307	1,731	1,385	1,154

*Standard errors are in brackets. ***,**: Significant at 2.5%, 5% (two-sided).

Table 3b. Parameter estimates Option Value Model for soybeans data

Parameter	Symbol	Discount Rate				
		r = 0.05	r = 0.075	r = 0.1	r = 0.125	r = 0.15
Option Value Parameter	a	1.77*** (0.28)	1.77*** (0.28)	1.87*** (0.28)	1.87*** (0.28)	1.87*** (0.28)
Mean Conversion Cost Per Acre	T	801.38** (219.25)	534.32** (146.18)	400.60** (109.59)	320.60** (87.73)	267.18** (73.11)
LLF Probability	ℓ	0.91 (0.05)	0.91 (0.05)	0.91 (0.05)	0.91 (0.05)	0.91 (0.05)
Standard deviation of ν error term	σ_v	0.42*** (0.05)	0.42*** (0.05)	0.42*** (0.05)	0.42*** (0.05)	0.42*** (0.05)
Implied Option Value ($/acre)		3,882	2,588	1,941	1,553	1,294

*Standard errors are in brackets. ***,**: Significant at 2.5%, 5% (two-sided).

the significant estimate for the option value ranges from $1,154 to $3,642 per acre. The implied option value follows from the calculation of $(e^a\text{-}1)T$.

Estimation for the two crops separately permits an assessment of differences in the crop specific option values; it may be that the risks associated with one crop particularly caused the average option value. Estimation of the model separately for soybeans yields similar estimates for the risk premium but higher estimates for the conversion costs (Table 3b). Both estimates are again significant. For corn there were insufficient observations to estimate the model separately.

The results in Tables 3a and 3b are subject to a restrictive model assumption regarding the option value even when estimated by crop; it is implicitly assumed that the option value is constant over the time period covered by the data. In view of the US Conservation Security Program, we have special interest in the option value in the most recent year. In addition, in May 2001 crop insurance was introduced for many organic crops which might have affected the option value. We find a significant reduction in the option value for the pooled soybeans-corn data of 53 percent (Table 4a). For soybeans alone the reduction in the option value was 30 percent (Table 4b). For 2001, the option value is calculated as $(e^{(a+\gamma)}-1)T$. The option value for 1997 follows from the calculation of $(e^a\text{-}1)T$, as before.

Table 4a. Option Value Model with Year Dummy for pooled corn and soybeans data

Parameter	Symbol	Discount Rate				
		r = 0.05	r = 0.075	r = 0.1	r = 0.125	r = 0.15
Option Value Parameter	a	2.04*** (0.46)	2.02*** (0.46)	2.03*** (0.46)	2.00*** (0.46)	2.00*** (0.46)
Mean Conversion Cost Per Acre	T	616.74** (286.60)	419.52** (195.10)	314.51** (146.29)	257.63** (120.01)	214.49** (99.91)
LLF Probability	ℓ	0.94 (0.05)	0.94 (0.05)	0.94 (0.05)	0.94 (0.05)	0.94 (0.05)
Standard deviation of ν error term	σ_v	0.54*** (0.07)	0.54*** (0.07)	0.54*** (0.07)	0.54*** (0.06)	0.54*** (0.06)
Dummy Variable for 2001	γ	-0.53*** (0.19)	-0.53*** (0.19)	-0.53*** (0.19)	-0.53*** (0.19)	-0.53*** (0.19)
Implied Option Value: 1997 ($/acre)		4,146	2,758	2,069	1,651	1,376
Implied Option Value: 2001 ($/acre)		2,184	1,450	1,088	866	722

*Standard errors are in brackets. ***,**: Significant at 2.5%, 5% (two-sided).

Table 4b. Option Value Model with Year Dummy for soybeans data

Parameter	Symbol	Discount Rate				
		r = 0.05	r = 0.075	r = 0.1	r = 0.125	r = 0.15
Option Value Parameter	a	1.74*** (0.25)	1.72*** (0.25)	1.72*** (0.25)	1.72*** (0.25)	1.72*** (0.25)
Mean Conversion Cost Per Acre	T	909.73** (232.79)	615.21** (158.82)	461.73** (119.24)	369.52** (95.46)	308.04** (79.60)
LLF Probability	ℓ	0.92 (0.05)	0.92 (0.05)	0.92 (0.05)	0.92 (0.05)	0.92 (0.05)
Standard deviation of ν error term	σ_v	0.40*** (0.05)	0.40*** (0.05)	0.40*** (0.05)	0.40*** (0.05)	0.40*** (0.05)
Dummy Variable for 2001	γ	-0.30** (0.14)	-0.30** (0.14)	-0.30** (0.14)	-0.30** (0.14)	-0.30** (0.14)
Implied Option Value: 1997 ($/acre)		4,256	2,832	2,124	1,699	1,416
Implied Option Value: 2001 ($/acre)		2,922	1,935	1,451	1,160	967

*Standard errors are in brackets. ***,**: Significant at 2.5%, 5% (two-sided).

Next, we use the estimates in Table 4a to calculate the annual 'green' payments required for a risk neutral conventional farmer to switch to organic farming. Assuming an interest rate of 10 percent, a conventional corn-soybean farmer would need to receive a one-time payment of $315 per acre as a compensation for the conversion cost and an additional $1088 per acre to cover the long run higher production and market risk of the organic practices. The sum of these two values equals an annual payment of $370 per acre for a 5-year contract and $228 per acre for a 10-year contract.

The CSP limit of $45,000 for total annual payments implies a farm could receive payments of $228 per acre per year for up to 197 acres. However, to qualify for Tier III payments, farmers need to address all resources of concern on their entire operation and this could be a limitation given the size of conventional corn-soybean farms. From the 2002 Census of Agriculture, it follows that on the average soybean farm 228 acres of soybeans were harvested. In addition, the average corn farm harvested 196 acres of corn. Most farms will grow both crops. In this context the CSP limit of

$45,000 for total annual payments seems more binding than the base payment restriction. The CSP base payment restriction of $13,000 per year would limit the farm size for enrollment in Tier III to 1,155 acre, assuming a rental rate of $75 per acre for dryland corn and soybeans.

5. Discussion and Conclusions

Based on option value theory, we have developed a theoretical model to assess the dollar compensation required for widespread conversion from conventional to organic farming. The empirical assessment for corn and soybean production provided strong evidence for the existence of an option value in addition to the cost of the transition. Our estimates for the option value decreased significantly between 1997 and 2001. One explanation for this phenomenon is that the value of postponing conversion decreased due to the introduction of crop insurance in 2001. However, the number of corn and soybean acres that were insured in 2001 (6,400) is small compared to the increase in U.S. certified organic corn and soybean acreage between 1997 and 2001 (104,500). Thus, perhaps a more plausible explanation for the drop in our option value estimates is that the increased supply of organic corn and soybeans led to lower price premiums.

The results are discussed in the context of the recently introduced Conservation Security Program, which will provide farmers in the U.S. with direct payments for organic practices. Assuming an interest rate of 10%, a conventional corn-soybean grower would need to receive a one-time payment of $315 per acre to compensate for the conversion cost and an additional $1,088 per acre to cover the long run higher production and market risks. The sum of these two values equals an annual payment of $228 per acre for a 10 year contact.

The annual payment required to induce the marginal farmer to switch to organic could be considerably lower if the Conservation Security Program were to continue beyond the initial enrollment period. For example, if farmers expected the program to last for two enrollment cycles, or 20 years, the threshold annual payment would drop to $165. However, to pursue this logic in a theoretically consistent way would require addressing the additional uncertainty associated with the possibility that the program will be terminated or fundamentally changed at some unknown point in the future. We leave this task for future research.

Even with a single enrollment cycle, the Conservation Security Program should increase the number of organically farmed acres in the U.S. by increasing the relative profitability of organic farming and by reducing income risk for certified and in-transition organic farmers. Because organic farms are more likely to qualify for CSP payments than conventional farms, the program should increase the relative expected profitability and reduce the income variability of organic farming. Furthermore, because enrollment does not require organic certification, farms in the transition process may also be eligible for CSP payments before they get certified. This should lessen the discomfort of the 3-year transition period when growers experience conversion costs but are not yet eligible for organic price premiums. Of course, an expansion of organic acreage due to the program would be tempered by lower prices that could result from an increase in the supply of organic products.

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