On how environmental stringency influences BMP adoption

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Abstract: There are relatively few Federal environmental regulations that influence agricultural production in the United States. However, many local and state environmental rules may influence the management practices on U.S. farms, which might affect costs of production and adoption of best management practices. Detailed analysis of corn farms yields insight into these relationships and suggests that stringent environmental regulations could increase the likelihood of adoption of certain conservation practices, all else equal, but not costs per unit of production.

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Introduction

Agricultural production affects the environment in many ways. Some impacts are positive – pleasant vistas and provision of wildlife habitat. However, many impacts are not positive – chemical and sediment runoff into lakes, streams, and estuaries. At the State and Federal level policies seek to encourage the positive impacts of crop production and to lessen its negative impacts. These typically rely on voluntary conservation programs, which provide education, technical assistance, and incentive payments to farmers for doing “good” things, such as retiring environmentally sensitive lands or adopting best management practices (BMPs) on land that remains in production.

Voluntary approaches can succeed when farmers’ concerns over environmental quality reflect those of society. When this is not the case and production decisions are based solely on private benefits, then farmers could under-invest in conservation if the costs of implementing and managing conservation practices are higher than conservation incentive payments.

In this paper, we examine whether evidence suggests that farmers in States with relatively strong environmental laws are adopting environmental-quality protecting management practices at higher rates than elsewhere, even when such laws are not aimed directly at crop production. This could be an indication that information about impaired environmental quality and the perceived likelihood of possible regulation in the future could spur farmers to adopt practices they ordinarily might not. To the best of our knowledge, no one study analyzes the impact of a state’s environmental stringency on the production of crops.

We examine these questions by first probing how the costs of producing corn are related to a state’s environmental stringency. Next, we estimate the influence of environmental stringency and other variables on a farmer's decision to adopt BMPs. We conclude with a discussion of the results and implications for future research.

Environmental Stringency

The influence of environmental regulations on production in manufacturing and some other industries has been studied by various researchers (e.g., Becker and Henderson, 1999; Suna and Zhang, 2001). The impacts of environmental regulations on agriculture production have also been analyzed. Isik (2004) assessed the relationship between environmental regulation and spatial structure of the U.S. dairy sector. His study concludes that counties with strict environmental regulations are likely to lose dairy inventories to the ones with less strict regulations. In addition, findings of panel analysis by Herath at al. (2005) suggest that the regions with less stringent environmental policies have increased their shares for hog and diary production in the U.S. Parallel to the pollution haven hypothesis, the study also suggests that state environmental regulations can indirectly or directly impact the size of the animal industry in the state by increasing the relative abatement costs of livestock producers.

Similarly, Metcalfe (2000) proposed that state water quality regulatory stringency on hog production in the US has a negative impact on the production of small hog feeding operations. Additionally, Metcalfe (2002) determined that stricter environmental regulations in the US will have a minimum effect on the international competitiveness of hog producers in the US while more stringent EU regulations might harm the international competitiveness of the hog producers in Europe.

However, environmental regulations might have different impacts on livestock and crop producing industries because, compared to the crop producers, animal feeding operations can change their production locations relatively easily. That is, in contrast to capital and labor, land is an immobile factor of production, so crop producers cannot move their production facilities from one region to the other. Thus, crop producers might face greater adaptation costs from new environmental regulations compared to livestock producers.

In 1997, the Environmental Law Institute published a report that analyzed the advantages of, shortcomings of and differences in the enforceable state laws used for prevention of nonpoint source water pollution, such as pollution runoff from cropland. Such differences in state environmental policies have important implications for the states whose economies heavily depend on the environmental resources.

Another potential source of pressure to adopt environmentally-friendly production practices is potential conflict with non-farm populations. In the suburban-rural fringe that is expanding in many parts of the country, people are moving into closer proximity to farms. This has given rise to citizen complaints about noise, odors, and other factors common to farm operations (see for example Clayton, 2005). Even if there are no regulations addressing these issues, farmers may implement practices for reducing the potential for conflicts over environmental quality issues.

Data

In our analysis we use farm-level agricultural and economic data from 2001 USDA Agricultural Resource Management Survey (ARMS) collected from corn producers. Corn production for grain occupied approximately 76 million acres of the U.S. land base in 2001, and was responsible for approximately $19 billion in production, and over 75 percent of the total grain produced in the U.S. (USDA-ERS, 2003). Because of both the coverage and the relative intensity of production on corn acres, the environmental management practices of corn producers may have a significant bearing on the overall environmental performance of U.S. agriculture.

The 2001 ARMS targets the population of farms within the 48 contiguous states, where a “farm operation” is defined as an establishment that sold or would normally have sold at least $1000 of agricultural products in a year (see USDA-ERS, 2006a). Surveyed farms have unequal probabilities of being selected for ARMS, and multiple sampling frames, using stratification and clustering procedures, are used to gather sufficient sample sizes to achieve reliability of the estimates. Full consideration of the sample design of ARMS is given to the estimates included herein. The 2001 ARMS gathered detailed data on production practices for corn, including the use of management practices and detailed costs and returns of the corn operation in isolation from the rest of the farm. Our survey of producers that planted corn with the intention of harvesting it for grain includes 1,543 observations. These observations are weighted in such a way that they expand to represent 94 percent of all acres planted to corn for grain (full coverage is not possible because detailed corn data was drawn from the 19 highest producing states, rather than the entire contiguous U.S.).

We used the ARMS data to estimate cost per bushel for each farm, following the recommendations of the American Agricultural Economic Association Task Force on Commodity Costs and Returns. Costs include operating costs and allocated overhead of corn production. Operating costs include seed, fertilizer, chemicals, custom operations, fuel, lubricants, electricity, repairs, and interest on operating capital. Fixed costs include hired and unpaid labor (imputed using off-farm wage rates based on location and operator characteristics), depreciation and interest for farm machinery, land (imputed using area cash rents,) taxes and insurance, and general farm overhead. Fixed costs were allocated to the corn operation based on share of corn within total farm value of production.

To capture the potential impact of economies of scale on the unit cost of production (*costbu* measured by $/bu), we use total farm value of production (*valprod* measured by $100,000's of sales) as a proxy to farm size. Larger farms may be more likely to invest in new practices, due to internal economies of size (Robinson and Napier, 2002). We consider how the share of crop and animal production in total state GDP (*agshare* measured by %) might capture external factors (external economies of scale) that impact the unit cost of production. Higher *agshare* is expected to decrease unit cost of production because of its positive impact on production (specialization, higher concentration of agriculture in the state, external economies impact).

We account for climate and soil conditions optimal for corn production using a dummy variable for farms located in the Heartland (*heart*), where more than half of corn farms are located and more than 70% of corn is produced (Foreman, 2001). The Heartland encompasses all of Iowa, Illinois, Indiana, and nearby the corn-producing counties in Arkansas, Ohio, Minnesota, Kentucky, Nebraska, and South Dakota (USDA-ERS, 2006b). Fields located on highly erodible land (*hel*) all else equal are expected to have both higher costs of production (higher runoff potential) and higher rates of BMP adoption (Claassen et al., 2004). Other geographically determined farm production and conservation practices that may affect the unit cost of corn production and conservation practice adoption include the use of irrigation (*irrigate*) and field drainage (*drain*). Irrigated farms have been found to be more likely to adopt nutrient-management related practices (Lambert et al., 2006).

In addition, we expect that farms located in counties with increased interaction between agricultural land use and urban-related activities face different pressures than farms located elsewhere. Interactions between urban-related population and farm production activities tend to increase the value of farmland, influence the production practices used, and elevate the probability that farmland will be converted to urban-related uses. It may also increase the probability that state-level environmental rules would be more rigorously enforced. We use county "population-interaction zones for agriculture" (PIZA) to represent areas of agricultural land use, where urban-related activities affect the economic and social environment of agriculture (USDA-ERS, 2005). The discrete county-level PIZA variable takes on values from 1 (lowest agricultural-urban interaction) to 4 (highest agricultural-urban interaction). We create a new variable (*pnew*), which combines the PIZA and the continuous population interaction index (USDA-ERS, 2005) to normalize the PIZA to be continuous between 0 and 4.

We consider several farm management variables that have also been shown to influence farm production costs and the adoption of conservation technologies. For example, Soule, Abebayehu, and Wiebe (2000) find that percentage of land owned by the farmer, or land tenure, (*ownshare* measured by %) is an important determinant in the adoption of conservation practices. We consider how having crop insurance (*cropins*) might influence costs of production and BMP adoption. If a farm uses manure (*manure*) as a fertilizer, it might be subject to greater regulatory scrutiny (Herath et al., 2005), thereby increasing the probability of employing a nutrient management plan. The farmer's yield goal (*yieldgoal*) might also affect per unit costs of production and conservation adoption -- higher yield goals would likely result in more intensive farming practices, which may or may not be consistent with some of the adoption technologies we consider (Johansson et al., 2004). Lastly, the primary occupation of the farm owner (*oper*) and his/her education level (*educ*) have been shown to be important in explaining farm management and technology adoption (Ferdnandex-Cornejo, Hendricks, and Mishra, 2005).

The data to measure regulatory stringency are limited; and several different indexes are used to measure it. Although different indexes use different criteria to measure the stringency, their main focus is to address different states' attempts to decrease environmental pollution. In our study, we use the stringency index (*index2000*) for the year 2000, developed by Herath et al. (2005). This index is formed for each state according to the presence or absence of seven regulations, which could influence farm-level operations (anti-corporate; limits on animal production; local administration and enforcement of regulations; bonding; state cost share program; manure restrictions; set-backs).

While we are examining if adoption of conservation practices are influenced by state-level environmental stringency or local-level interactions with urban populations, some BMPs will be adopted for other financial reasons. For example, participating in a voluntary conservation program and receiving cost-share payments (*costshare*) is likely correlated to adoption of conservation practices (Robinson and Napier, 2002; Lambert et al., 2006). (Note that our data did not specify which practices were being supported, only that the farmer received a cost share payment). Or it may be that some conservation practices enhance efficiency of input use or improve soil productivity over time. For example, nutrient management planning has been found to increase returns for livestock farms (Bonham, Bosch, and Pease, 2004; VanDyke et al., 1999).

However, the joint adoption decision of many conservation BMPs could also be influenced by environmental stringency for the reasons discussed earlier. We examine the use of conservation tillage, or having residue cover of at least 30% at the time of planting, (*residue*);

building grassed waterways (*grass*), which help filter field runoff from drainage channels; use of filter strips at the edge of the corn field (*strip*), which helps reduce runoff from farm fields; testing the field for nitrogen and phosphorus content (*test*), which enable more efficient applications of commercial and manure nutrients; and using a yield monitor on harvesting equipment (*precag*), which also enhances the efficiency of input use on the field. We also consider how conservation planning (erosion plan – *eros*; manure management plan – *manman*; and commercial fertilizer plan – *fert*) might be affected by environmental stringency.

Models

We test two hypotheses concerning environmental stringency. First, we expect that unit costs of production will be higher all else equal as a function of environmental stringency as found in the regulation literature (e.g., Sunding, 1996; Antle, 2000; Isik, 2004). Second, we expect that increasing environmental stringency and close proximity to urban areas are associated with a greater likelihood of BMP adoption.

Costs of Production

In the first regression, we regress unit cost of corn production on a group of variables. We used the following simple linear regression model to assess the factors influencing the unit cost of corn production: $C_i = \beta_0 + \sum_{j=1}^{J} X_i + \varepsilon_i$, where C_i is the unit cost of production for farm field *i* divided by bushels harvested; X is the vector independent variables (*agshare, valprod, heart, drain, hel, yieldgoal, educ, oper, irrigate, cropins, ownshare, manure, costshare, index2000, and pnew;* see table 1); β is the vector of parameter estimates; and ε_i is the random error term. We estimate this equation using OLS using robust standard errors (White, 1980) to correct for potential heteroskedascity.

Technology Adoption

Our next regression examines a set of interrelated conservation practices, where it is likely that the decision to adopt one practice is correlated to other conservation management decisions. Here we consider residue management, yield monitoring, use of grassed waterways, development of an erosion plan, development of a manure management plan, development of a commercial fertilizer plan, nutrient soil testing, and the use of filter strips (see table 1). Corn farms show a range of adoption rates – ranging from 34% of farms employing conservation tillage to 7% of corn farms with filter strips on the edge of the corn field. In such a setting it is appropriate to use a multivariate approach to the probit estimation of adoption (Cooper, 2001). For our model, we estimated the following model for each farmer *i* using conservation practice *j*: $y_{ij}^{*} = \beta' X_{ij} + \varepsilon_{ij}$, where $y_{ij} = 1$ if $y_{ij}^{*} > 0$ and $y_{ij} = 0$ otherwise. Here X is the same matrix of dependent variables used to examine unit costs of production (i.e., *agshare, valprod, heart, drain, hel, yieldgoal, educ, oper, irrigate, cropins, ownshare, manure, costshare, index2000,* and *pnew*). ε_{ij} denotes the error terms with multivariate normal distribution where each has a mean of zero and variance of 1. Variance-covariance matrix of error terms includes rho-correlations $\rho_{ij} = \rho_{ji}$ off the diagonal. We have eight equations where LHS (y*) represents the likelihood of adopting different, possibly interrelated, conservation practices.

The simulated maximum likelihood technique (SML) is used to estimate our model. As Greene (2002) emphasized, MSL estimation has been used by a growing number of studies (e.g., Cooper, 2001; Belderbos et al., 2004). Following Cappellari and Jenkins (2003), our multivariate probit models are estimated using Geweke-Hajivassiliou-Keane (GHK) simulator. Eight dimensional normal probability distribution functions are simulated to evaluate multivariate probit likelihood functions.

Results

Our first hypothesis was that environmental stringency or contact with non-farming populations increases the unit cost of production. This was not borne out by the results (table 3). The estimated affect of environmental stringency on costs *does not* have the expected sign, although the statistical significance is weak. A negative coefficient indicates that all else equal, farms located in states with higher environmental stringency are likely to have *lower* costs of production. This could indicate that there are unaccounted differences in the costs of production in regions outside of the Heartland, which are being picked up by the stringency variable; i.e., corn farms not in the Heartland with lower costs of production might be located in states having higher environmental stringency like Wisconsin. Or, it might indicate that environmental stringency encourages the adoption of best management practices, which could lower costs relative to harvests. The variable capturing the interaction between agricultural production and urban population centers (*pnew*) does have the expected sign (positive), but it is not significant in the unit cost regression.

Most coefficients for the other variables have the expected sign. The cost per bushel of corn production is lower in states with a higher share of crop and animal production in total state GDP (*agshare*), indicating the existence of external economies to scale. The costs of corn production per bushel were slightly lower for farms with higher total value of farm production (as a proxy to farm size). The negative coefficient implies increasing internal economies of scale;

i.e., farms with a larger value of production have higher unit costs of production for corn. Farmers reporting higher yield goals are likely to have lower costs relative to harvests. Farms that use irrigation have higher per unit costs. Full-time farm operators (*oper*) have lower unit costs of corn production. As was found in Aigner, Hopkins, and Johansson (2003) owning a larger share of cropped land (*ownshare*) is found to decrease costs of production.

The second hypothesis was that increasing environmental stringency or contact with the non-farming population is associated with a greater likelihood of BMP adoption. The results found that the adoption of two practices, grassed waterways and an erosion plan were influenced by environmental stringency (table 4). Grassed waterways are an effective practice for filtering sediment and chemicals for field runoff, thus protecting water resources. It is generally not a practice that increases productivity, so its use constitutes a pure cost to the farmer.

Adoption of an erosion plan could be for protecting soil productivity, a private benefit. However, an erosion plan also addresses offsite impacts of erosion, and is often implemented in conjunction with other practices, such as nutrient management. Table 5 indicates that there is significant correlation between an erosion plan (*eros*) and all other types of conservation practices included in the analysis, indicating that an erosion plan is complementary to the other practices. Our results could be an indication that environmental stringency is influencing the adoption of practices that address particular problems. However, since problems vary across states, only the erosion plan, which is often implemented in conjunction with other practices, is significant in the multivariate probit model.

Proximity to urban areas did not have the expected influence on practice adoption. The only equation in which it was significant was adoption of grassed waterways, but with the wrong sign. One possible explanation could be that if farmers in these areas expect to sell their land for development in the relatively near term, they might be reluctant to investment in conservation practices.

Estimation results from the multivariate probit model suggest that share of agricultural production in total GDP of a state tends (*agshare*) to increase the probability of adoption of conservation tillage, nutrient soil testing, and yield monitoring. Farms with higher total value sales (*valprod*) show an increased use of manure management plans, perhaps capturing the impact of increasing manage management requirements for large livestock operations (Metcalf, 2000). Having a field classified as highly erodible (*hel*) increases the probability of the farm using conservation tillage, managing grass waterways, and development of an erosion plan. These practices could be required under the Conservation Compliance provisions of the 1985 Food Security Act as a condition for receiving program benefits. Setting higher yield goals (*yieldgoal*) is likely to increase the use of all conservation management practices except for filter strips.

A farmer that has attended college (*educ*) is more likely to use yield monitors when harvesting his/her crop, but is no more or less likely to employ the other conservation practices that we examined. Full-time farmers (*oper*) are more likely to have nutrient management plans (*manman* and *fert*).

Irrigated farms (*irrigate*) are more likely to be tested for soil nutrient content, but less likely to have erosion plans. Farms with tile drainage are also likely to be tested for soil nutrient content and to use filter strips. Farms using manure nutrients as fertilizer (*manure*) are more likely to have a manure management plan, but less likely to use a yield monitor while harvesting. While most farms report having some type of crop insurance (71 percent), those that do not are more likely to use grassed waterways, but less likely to use yield monitors. Farmers with more tenure (*ownshare*) are more likely to develop erosion plans. This suggests that those farmers that rent a relatively high proportion of their operation might be a group to target for adoption of this BMP, which is highly correlated to other conservation practices.

Looking at explicit carrots (receipt of conservation incentive payments) and possible sticks (close interaction with urban populations and state-level environmental stringency), we find that receiving cost-share payments (*costshare*) positively affects the probability of using nutrient testing, managing grassed waterways, developing erosion plans, and use of filter strips. In addition, those farms located in states with a higher environmental stringency, all else equal, are more likely to have grassed waterways and erosion plans. However, having a closer interaction with urban populations is found to have relatively little influence over the adoption of BMPs, with the exception of grassed waterway.

Conclusions

In our analysis we did find evidence that environmental stringency might be influencing the adoption of conservation practices. While environmental stringency could accelerate the adoption of environmental-quality protecting practices, we cannot say whether it provides enough of an incentive for policies based on voluntary adoption to adequately protect water quality.

In our study, we did not analyze the change in the structure of these industries. Instead, assuming no change in the production locations and using cross-sectional farm data, we tested the hypothesis that state and local environmental stringency as measured by an index (Herath et al., 2001) had a positive impact on the unit costs of corn production in 2001 and on the adoption of conservation technologies. The regression results do not support our hypothesis about costs --

increasing stringency does show a weak association with lower unit costs of production. This may be explained partially by the adoption of conservation technologies, which may in fact lower costs relative to yield, thereby improving the farm's bottom line. Increasing stringency is shown to be positively related to the adoption of two conservation technologies – grassed waterways and the development of farm erosion plans. Related to this question is the result that many conservation technologies are treated by producers as a bundle of management decisions, which are not independent of each other. Developing an erosion plan is positively related to both environmental stringency and the adoption of all other conservation practices examined.

One logical next step in this research would be to assess these relationships over time. It is likely that there is an endogenous relationship between stringency and past adoption practices, difficult to discern using cross-sectional data. Similarly, tracing the impact of these conservation practices by reductions in soil and chemical runoff would enrich the conclusions we might draw from our analysis.

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Table 1. Conservation Management Practices

Variable	Variable Name	Mean	Units
Grassed waterways	grass	0.27	0 or 1
Filter strips	strip	0.07	0 or 1
Conservation tillage	residue	0.34	0 or 1
Soil nutrient testing	test	0.30	0 or 1
Yield monitors	precag	0.16	0 or 1
Manure nutrient plan	manman	0.04	0 or 1
Commercial fertilizer plan	fert	0.09	0 or 1
Erosion plan	eros	0.25	0 or 1

Table2. Sample Means

Variable	Variable Name	Mean	Units
Observations	1,543.00		
Households	309,455.00		
Stringency	index2000	3.69	index
Continuous PIZA	pnew	0.85	index
Farm Size	aplfarm	223.76	acres
Field Size	aplfield	42.12	acres
Total Production Value	valprod	1.94	$100,000's
Highly erodible field	hel	0.19	0 or 1
Cost share received	costshare	0.03	0 or 1
Crop insurance	cropins	0.62	0 or 1
Use of manure	manure	0.20	0 or 1
Field drainage	drain	0.38	0 or 1
Yield goal	yieldgoal	140.94	bu's
Yield goal	yield	128.57	bu's
Tenure	ownshare	0.53	%
Irrigation	irrigate	0.09	0 or 1
Unit cost of production	costbu	3.37	$/bu
Agricultural share of state GDP	agshare	0.02	%
Heartland	heart	0.58	0 or 1
Full-time operator	oper	0.76	0 or 1
Attended college	educ	0.15	0 or 1

Table 3. Variable effects on unit costs of corn production

Variable	Coef.	P>|t|
agshare	-0.37	0.00
valprod	-0.02	0.07
heart	-0.19	0.56
drain	0.11	0.58
hel	-0.08	0.80
yieldgoal	-0.04	0.00
educ	-0.04	0.83
oper	-0.80	0.03
irrigate	1.67	0.00
cropins	0.29	0.40
ownshare	0.61	0.04
costshare	0.00	1.00
manure	0.19	0.39
index2000	-0.14	0.14
pnew	0.14	0.32
constant	9.83	0.00
R-squared	0.16	

Table 4. Multivariate probit results*

	residue		test		grass		eros	
Variable	Coef.	P>|z|	Coef.	P>|z|	Coef.	P>|z|	Coef.	P>|z|
agshare	0.17	0.00	0.08	0.05	0.03	0.51	0.03	0.50
costshare	0.44	0.16	0.47	0.09	0.54	0.07	0.80	0.03
valprod	0.01	0.31	0.01	0.30	-0.01	0.39	-0.01	0.62
heart	-0.08	0.47	0.01	0.92	0.28	0.02	0.10	0.42
drain	-0.03	0.80	0.38	0.00	0.07	0.57	-0.13	0.33
hel	0.49	0.00	-0.14	0.27	0.66	0.00	1.47	0.00
yieldgoal	0.00	0.02	0.01	0.01	0.00	0.09	0.01	0.00
educ	0.09	0.51	0.20	0.11	-0.03	0.85	0.18	0.21
oper	-0.25	0.04	0.26	0.04	0.21	0.13	0.10	0.47
irrigate	-0.15	0.55	0.92	0.00	-0.21	0.67	-0.89	0.00
cropins	0.12	0.39	0.02	0.92	-0.34	0.06	-0.06	0.69
ownshare	-0.09	0.47	0.07	0.61	-0.09	0.61	0.39	0.00
manure	-0.22	0.10	0.01	0.95	0.00	0.98	-0.01	0.94
index2000	-0.02	0.73	-0.01	0.89	0.17	0.00	0.16	0.00
pnew	0.02	0.72	-0.05	0.47	-0.18	0.02	0.07	0.34
_cons	-1.06	0.00	-1.85	0.00	-1.86	0.00	-3.36	0.00

	manman		fert		precag		strip	
Variable	Coef.	P>|z|	Coef.	P>|z|	Coef.	P>|z|	Coef.	P>|z|
agshare	0.05	0.47	0.01	0.90	0.08	0.04	0.06	0.31
costshare	0.37	0.32	0.43	0.22	-0.58	0.21	1.38	0.00
valprod	0.02	0.00	0.01	0.22	0.02	0.04	-0.01	0.54
heart	0.25	0.21	0.34	0.03	0.14	0.29	0.08	0.64
drain	-0.09	0.66	0.08	0.63	0.14	0.27	0.48	0.01
hel	0.08	0.73	0.05	0.74	0.18	0.20	0.10	0.56
yieldgoal	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.62
educ	0.16	0.44	-0.21	0.24	0.38	0.01	0.23	0.20
oper	0.90	0.00	0.45	0.04	0.24	0.12	0.20	0.28
irrigate	-0.36	0.21	-0.12	0.58	-0.17	0.43	-0.39	0.21
cropins	0.03	0.84	-0.09	0.61	0.37	0.01	-0.06	0.78
ownshare	0.29	0.21	0.23	0.20	-0.14	0.31	-0.12	0.53
manure	1.03	0.00	0.06	0.72	-0.37	0.03	-0.01	0.95
index2000	0.02	0.78	0.06	0.31	-0.04	0.34	-0.05	0.40
pnew	0.09	0.40	-0.08	0.38	-0.04	0.59	0.00	0.97
_cons	-4.81	0.00	-3.86	0.00	-3.12	0.00	-1.66	0.00

* Log-likelihood = -931,593.04; a chi-square test with 120 degrees of freedom rejects the null (that there is effect of the independent variables on the probability of BMP adoptions) at the 0.0000 level.

Table 5. Rho-correlation matrix for conservation practices

Practice	residue	test	grass	eros	manman	fert	precag	strip
residue	1.00							
test	0.04	1.00						
grass	0.04	0.04	1.00					
eros	0.20[a]	0.01	0.19[a]	1.00				
manman	-0.06	0.18	0.33a	0.37[a]	1.00			
fert	0.20[a]	0.37[a]	0.26[a]	0.38[a]	0.46[a]	1.00		
precag	0.04	0.14[a]	0.06	0.13[b]	0.15	0.10	1.00	
strip	0.25[a]	0.01	0.24[a]	0.38[a]	0.16	0.04	0.05	1.00

a/ indicates significance at the 5% level; b/ indicates significance at the 10% level.