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# Economic Impacts of Adoption of Best Management Practices by Crawfish Producers: The Role of the Environmental Quality Incentives Program

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This study investigates reasons for adoption of best management practices (BMP), crawfish farmers' participation in the Environmental Quality Incentives Program (EQIP), and economic impacts of BMP adoption using data from a 2008 survey of crawfish producers. Most-cited reasons for BMP adoption are farmers' perceptions of increases in profit and long-run productivity. Land tenancy, education, double-cropping or crop rotation, and proximity to a stream influence EQIP participation. Perceptions of economic profits depend on the practices used. Participation in EQIP negatively impacts farmers' perceptions of profitability from adopting BMPs. The results underscore the importance of economic incentives in promoting BMP adoption.

**Key Words:** conservation practices, conservation programs, crop rotation, double-cropping

Like most agricultural operations, crawfish farms can generate non-point source water pollution via erosion and discharges of effluent that contain contaminants. To combat non-point source pollution and provide benefits to wildlife, the U.S. Department of Agriculture (USDA) encourages farmers to adopt best management practices (BMPs) through its Environmental Quality Incentives Program (EQIP). A number of studies have addressed BMP adoption in agriculture and factors that influence it (Gould, Saupe, and Klemme 1989, Cooper and Keim 1996, Rahelizatovo and Gillespie 2004). Nyaupane and Gillespie (2011) found that the main reasons cited by crawfish producers for failing to adopt BMPs were lack of familiarity with them or perceptions that BMPs were not applicable to their operations. We are not aware

of any studies that have closely examined (i) the specific reasons for farmers' BMP adoption, (ii) factors that influence the use of EQIP cost-share funds to implement such practices for crawfish production, or (iii) the impact of specific BMPs on farmers' perceptions of their farms' profitability. This study addresses these issues and enhances our understanding of the importance of economic incentives in encouraging BMP adoption.

A number of U.S. federal programs have been implemented since the 1930s to encourage adoption of conservation practices, including the Federal Food, Drug, and Cosmetic Act of 1938 (21 U.S.C. § 301 et seq.), the Federal Water Pollution Act of 1948 (33 U.S.C. 1251–1376), and programs in various farm bills over the years. Perhaps the most significant increase in conservation effort appeared in the 1985 Farm Bill (P.L. 99-198). Five years later, the Water Quality Incentives Program in the 1990 Farm Bill (P.L. 101-624) provided economic incentives to adopt BMPs, but the most significant program to encourage adoption of BMPs to date has been the EQIP, which was introduced in the 1996 Farm Bill (P.L. 104-127). The EQIP, under which the government shares the initial cost to farmers of implementing BMPs, was subsequently expanded

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in the 2002 and 2008 Farm Bills (Stubbs 2010). Few studies have addressed the economic impacts of BMPs (see Valentin, Bernardo, and Kastens 2004) or EQIP participation (see Obubuafo et al. 2008).

### **The Environmental Quality Incentives Program**

Agricultural producers can apply to the EQIP, a voluntary program, and receive financial and technical support for BMP adoption for up to ten years, the goal of which is attainment of federal, state, and local environmental quality standards (Natural Resources Conservation Service 2011). The EQIP is administered through USDA's Natural Resources Conservation Service (NRCS) and is the nation's largest agricultural conservation program with total funding of \$130 million in 1996, a figure that was slated to rise to \$1.75 billion in 2012 (Stubbs 2010). Texas, California, Colorado, and Minnesota were the four largest recipients of EQIP funds per state for 2005 through 2008 (Stubbs 2010). Of the program's total annual expenditures, 60 percent of the funds are allocated to conservation practices related to livestock production. In 2006, NRCS established national priorities for implementation of the EQIP that focused on reducing non-point source pollution from affected water bodies, conserving water resources, reducing emissions of greenhouse gases, reducing soil erosion and sedimentation, and promoting endangered species habitats (Stubbs 2010). Farmers approved by the program can receive up to 75 percent of the total cost of adopting BMPs in their operations with support of up to 90 percent for disadvantaged farmers.

In the next section, we discuss the survey methodology used in the study, questions that were put to producers in the survey, and the econometric methods used in the analysis. The last two sections of the paper are the empirical results and conclusions.

### **Data and Methods**

#### *Mail Survey*

The extent of adoption of BMPs and EQIP participation among crawfish producers in Louisiana was assessed via a mail survey

conducted in the fall of 2008 that employed Dillman's (1978) Total Design Method. In addition to questions on general farm structures and demographics, the survey addressed specific crawfish production systems such as adoption of BMPs, record-keeping systems, use of tenancy arrangements, participation in the EQIP, and crawfish production systems. Contacts with crawfish producers consisted of informing producers via *Crawfish News*, a newsletter to Louisiana producers, that they would receive the questionnaire; sending of the questionnaire with a cover letter that explained the purpose and usefulness of the study and a postage-paid envelope for returning the survey; sending of a postcard reminder approximately ten days later to nonrespondents; sending, ten days after the postcard reminder, of a questionnaire and a second cover letter to nonrespondents that encouraged them to complete the survey; and, finally, sending of a second postcard reminder ten days after the second copy of the survey. First-class mail was used for all mailings.

Of the 770 producers to whom surveys were sent, 75 returned completed questionnaires. Adjusted for 79 undeliverable mailings and 185 survey recipients who did not produce crawfish during the 2007/08 season, the response rate was 15 percent.

We compared our survey statistics with results from the 2005 *U.S. Census of Aquaculture* (National Agricultural Statistics Service 2005), which identified 605 crawfish farms in Louisiana, 433 of which used crop land for production. In the census report, the average size of a crawfish operation was 176 acres; our estimate of average size is 211 acres. In terms of land tenancy, the census reported that 49 percent of Louisiana aquaculture producers leased land and that 54 percent of the land used for crawfish production was leased. We estimate that 63 percent of Louisiana crawfish producers leased land and that 42 percent of the land used for crawfish production was leased. More extensive comparisons of our sample to other estimates can be found in Nyaupane and Gillespie (2011) and in Gillespie and Nyaupane (2010), which generally show that the farms in our sample are larger than those in the aquaculture census or in estimates for 2008 by the Louisiana Cooperative Extension Service (2009). It is common for respondents to mail surveys to be operators of farms that are

larger than average (e.g., Gillespie, Kim, and Paudel 2007). Though we would have preferred a higher return rate, personnel with the Louisiana State University Agricultural Center who have extensive experience working with the industry were enthusiastic about our response rate given their past experiences with collecting data from crawfish farmers.

We are not aware of any norm that has been established for the number of farmers who respond to surveys since response rates have varied widely according to the population being surveyed and the nature of the survey. Some recent studies have realized relatively high rates of response to mail surveys, including one by Patrick et al. (2007) of Indiana and Nebraska hog producers at 26 percent and another by Gillespie, Kim, and Paudel (2007) of Louisiana beef producers at 41 percent. Others have experienced rates similar to or lower than ours, such as surveys of cotton farmers in the southeastern United States (Banerjee et al. 2008), 10 percent; Louisiana dairy farmers (Paudel et al. 2008), 15 percent; Kentucky tobacco farmers (Pushkarskaya and Vedenov 2009), 14 percent; and limited-resource farmers in the southeastern United States (Bergtold and Molnar 2010), 16 percent.

#### *Reasons for Adopting Best Management Practices*

Surveyed producers were asked whether they had adopted eighteen EQIP-eligible BMPs and, if so, to select one of five statements as best describing their reasons for adopting: (i) "Yes, it leads to increased profit;" (ii) "Yes, it is good for the environment;" (iii) "Yes, I have been encouraged / required to do so;" (iv) "Yes, it's good for long-run land productivity;" and (v) "Yes, this practice was established by the landowner or another tenant." We calculated the percentage of adopters who selected each reason. Nonadopter participants were asked similar questions regarding their reason for choosing not to adopt in Nyaupane and Gillespie (2011). We recognize that multiple motivations may influence farmer adoption decisions. We asked them to choose the one reason that best reflected their motivation because we were concerned that asking them to rank their reasons for adoption on eighteen practices would lead to respondent fatigue and a lower survey response rate. Understanding why

farmers adopt BMPs extends the work of previous studies that analyzed nonadoption (Nyaupane and Gillespie 2011, Gillespie, Kim, and Paudel 2007).

#### *EQIP Participation*

To gain further insight into incentives for BMP adoption, it is helpful to understand factors that influence EQIP participation. Our survey asked farmers whether they had participated in any government cost-sharing program such as the EQIP while implementing a BMP. Farmers who answered affirmatively were then asked to check any of the eighteen practices listed for which they were receiving cost-share support. In determining whether to adopt a BMP, farmers maximize utility, which is generally a function of profit, environmental concerns, and long-run land productivity. The EQIP effectively allows for a shift in a farmer's budget and thus can allow for adoption of BMPs that might not be adopted otherwise.

Since we were interested in the probability of participation by a producer of a particular description, the probit model was appropriate for determining the impact of factors that influence crawfish producers' decisions about EQIP participation. Using the probit model, which assumes a normal distribution, we modeled the probability of EQIP participation as shown in Greene (2008):

$$(1) \quad Pr(Y = 1) = \int_{-\infty}^{x'\beta} \phi(t) dt = \Phi(x'\beta)$$

where  $\phi(\cdot)$  denotes the standard normal distribution,  $(Y = 1)$  suggests participation in the EQIP,  $x$  represents independent variables expected to influence participation, and  $\beta$  represents parameter estimates. Marginal effects for continuous variables were estimated as

$$(2) \quad \frac{\partial E[Y/x]}{\partial x} = \Phi(x'\beta)\beta$$

and marginal effects for dummy variables,  $d$ , were estimated as

$$(3) \quad Pr[Y = 1|\bar{x}_*, d = 1] - Pr[Y = 1|\bar{x}_*, d = 0]$$

where  $\bar{x}_d$  refers to all variables other than  $d$  held at their mean values.

#### *Factors Hypothesized to Influence Farmers' EQIP Participation*

Since the EQIP provides farmers with an economic incentive to adopt BMPs, we expected that factors that influence farmers' adoption of BMPs would also generally influence EQIP participation. In our model, *ACRES* is the number of acres on the farm divided by 1,000 for estimation purposes. Operators of larger-scale farms have generally been more likely to adopt technology in general (Feder, Just, and Zilberman 1985, El-Osta and Morehart 1999) and BMPs specifically (Gillespie, Davis, and Rahelizatovo 2004) and are typically more aware of and interested in applying for EQIP funds (Obubuafo et al. 2008). Larger operations also can spread the initial investment required to implement BMPs over a greater quantity of output, which reduces the average cost of production. While the EQIP provides an incentive to producers regardless of the scale of operation, a significant capital investment is still required since EQIP funds pay only part of the adoption cost.

For a producer who rented land for crawfish production, the variable *CASH* denoted cash provisions in one or more of the leases and *SHARE* represented profit-share provisions in a lease. Previous research has shown that various forms of land tenure affect BMP adoption (Soule, Tegene, and Wiebe 2000). Historically, landowners have generally been more likely to adopt BMPs and thus would be more likely apply for EQIP funds. Tenants were classified into *CASH* and *SHARE* leases since both types are common in the crawfish industry, and, according to Soule, Tegene, and Wiebe (2000), conservation adoption patterns vary significantly with the type of lease.

*ROTATION* was a dummy variable indicating whether crawfish production was rotated with rice, soybeans, and/or a period of fallow. *DOUBLECROP* was a dummy variable that indicated that crawfish production was double-cropped with rice. In a rice-crawfish double-crop system, rice and crawfish are produced in the same field each year. Generally, rice is planted in late spring and harvested in late summer; in mid-fall, the field is reflooded, and crawfish are harvested from fall through early spring. The field is then drained and replanted with rice. Two types of rotational systems are common:

a rice-crawfish-fallow rotation and a rice-crawfish-soybean rotation. In the former, first rice and then crawfish are produced the first year, and the field is left fallow the second year. In the latter, soybeans replace the fallow period of the rice-crawfish-fallow rotation. Farmers with *ROTATION* and *DOUBLECROP* systems are expected to be greater EQIP participants because BMPs have the potential to impact not only crawfish but also rice and/or other crops in rotation.

*STREAM* identified operations in close proximity to a natural waterway, which should increase EQIP participation. Having a stream flowing through the farm is advantageous for irrigation, but streamside crop production also may pollute the waterway. Farmers were asked "how far from your crawfish farm is the nearest stream or river?" and could respond positively or negatively to the answer "a stream/river runs through my farm." *STREAM* was used as a dummy variable in our study. Obubuafo et al. (2008) found an unexpected negative impact of *STREAM* on applications for EQIP funds among cattle-raisers.

Two variables in the analysis represented operator characteristics: *AGE* and *COLLEGE*. *COLLEGE* was a dummy variable that indicated that the producer had a four-year college degree. The age and education of farmers affect their BMP adoption decisions (Zepeda 1994, Soule, Tegene, and Wiebe 2000) and their awareness of and willingness to participate in the Conservation Reserve Program (McLean-Meynsse, Hui, and Joseph 1994). McLean-Meynsse, Hui, and Joseph (1994) found that older producers were more frequently participants in the Conservation Reserve Program and other cost-share programs, and Obubuafo et al. (2008) found that older producers were more likely to be aware of and apply for EQIP funds. We expected that education would affect technology-adoption decisions (Feder, Just, and Zilberman 1985, Soule, Tegene, and Wiebe 2000) since education typically enhances one's ability to process information. Obubuafo et al. (2008) found that education was negatively associated with applications for EQIP funds. They argued that farmers with more education had generally adopted essential BMPs earlier using their own funds and so had little need to apply for EQIP funding.

*CRAWFISHINCOME* measured the portion of farm income derived from crawfish operations. Crawfish farmers' involvement in multiple enterprises, usually involving crops, would encourage them

to be more informed about government programs for those enterprises. In the absence of a crawfish-specific commodity-support program, we expected farmers who produce only crawfish to be less aware of the array of government programs available to them, including the EQIP. *OFF-FARM JOB* was a dummy variable included to determine the effect of farmers' off-farm incomes on EQIP participation. Obubuafo et al. (2008) found that farmers who have off-farm employment tend to be less aware of and less likely to apply for EQIP funds.

#### *The Impact of Adoption of Best Management Practices on Farm Profitability*

The third part of our study addresses farmers' perceptions of the impact of BMPs on farm profitability. Following the BMP adoption questions in the survey was a question regarding farmers' perceptions of the economic impacts of BMP adoption: "How do you think the combination of BMPs you have adopted has impacted your profit as compared to if you hadn't adopted them?" Available responses were in 10-percentage point intervals: (1) Lowered my crawfish profit by 21 percent or more; (2) Lowered my crawfish profit by 11 percent to 20 percent; (3) Lowered my crawfish profit by 1 percent to 10 percent; (4) Did not impact my crawfish profit; (5) Increased my crawfish profit by 1 percent to 10 percent; (6) Increased my crawfish profit by 11 percent to 20 percent; and (7) Increased my crawfish profit by 21 percent or more. Respondents were asked to select one.

An interval regression model was used to analyze the impacts of adopted BMPs, the EQIP, farm characteristics, and farmer demographics on farmers' responses to the economic impact question to determine their perceptions of the profitability of the BMPs they implemented. As shown in Wooldridge (2010, p. 783), when using the interval regression model, the dependent variable  $w$  is defined as

$$(4) \quad \begin{aligned} w &= 0 \text{ if } y \leq r_1 \\ w &= 1 \text{ if } r_1 \leq y \leq r_2 \\ &\vdots \\ w &= J \text{ if } y > r_J \end{aligned}$$

where  $r_1 < r_2 < \dots < r_J$  are known interval limits. The interval regression estimators are maximum-likelihood estimators with an underlying homoskedastic normal population distribution (Wooldridge 2010, p. 783). Under the interval regression model, the parameter estimates,  $\beta$ , are directly interpreted as marginal effects.

Independent variables in this model include adoption of BMPs, farming system and farmer demographics, and receipt of EQIP cost-share benefits for BMP adoption. Among the eighteen EQIP-eligible BMPs applicable to crawfish production, we selected the twelve that had been adopted by ten or more producers for analysis. In cases where only a few farmers had adopted a practice, there likely would not have been enough observations from which to draw inferences. Furthermore, when the other practices were included, none of the six BMPs was significant at  $P \leq 0.05$ . The truncation from eighteen to twelve BMPs, however, was tested using the Hausman (1978) specification test and significant differences were found at  $P \leq 0.05$ . Thus, to account for the six BMPs adopted by less than ten producers, we constructed a dummy variable, *OTHER6BMPs*, that indicated that one or more of the six rarely selected BMPs had been adopted by a farmer. Tests of this model against the full (eighteen BMP) model generated no significant differences, so we substituted *OTHER6BMPs* for explicit inclusion of the six BMPs with less than ten adopters.

Expected signs in relation to economic impact may differ by individual BMP. Some recent studies that examined the impact of technology adoption on farms' financial performance corrected for selection bias under the theory that better economic performance might arise because of self-selection of more productive farmers into a technology rather than due to the technology itself (McBride, Short, and El-Osta 2004, Tauer 2006). However, in our analysis, all of the producers had adopted one or more BMPs so all were adopters. In addition, our dependent variable was not simply an outcome, such as one year's profit, as was the case with the aforementioned technology adoption studies. We evaluated farmers' perceptions of the impact of a chosen set of BMPs on profitability relative to the profit that likely would have been earned if the BMPs had not been adopted.

To account for adoption of multiple BMPs, the variable *BMPs* $\geq 5$ , which indicated that five or more BMPs had been adopted, was included in

the model. Five was selected because it was the median number of BMPs adopted by crawfish farmers.

*OWN* was a dummy variable that indicated that the farmer owned the entire crawfish farm. Farmers who own the land were expected to perceive BMPs as having a greater positive impact on crawfish profitability since the productivity benefits of many BMPs are longer-term in nature and thus accrue to the owner rather than the renter.

The variable *DOUB-ROTATION* indicated that the crawfish farmer was involved in a rotation or double-crop system and that another crop, in most cases rice, was produced on the same land as crawfish. Beattie, Taylor, and Watts (2009, p. 196) discussed the technical relationship between two products produced from a single factor. Given a multiproduct production function with two products (rice and crawfish) and a factor of production (a BMP), the marginal productivity of the BMP in the production of rice (crawfish) would increase with the addition of crawfish (rice) if the two products are technically complementary. Likewise, the marginal productivity of each product would remain unchanged or decrease if the products are technically independent or competing, respectively. In other words, if a BMP increased (decreased) the productivity of crawfish when double-cropped or rotated with another crop such as rice, the products would be technically complementary (competing) with respect to the practice and a positive (negative) sign for perceived profitability associated with *DOUB-ROTATION* would be expected. More highly educated farmers are generally assumed to be better managers, so a positive sign for *COLLEGE* would suggest that individuals with a higher level of education adopt BMPs more effectively.

We included a variable for farmers' participation in the EQIP. Cost-sharing with the EQIP could increase the net benefit of BMP adoption since the full cost of implementing BMPs would not be borne by the adopter, leading to a greater positive impact on profitability. On the other hand, farmers may participate in the EQIP to adopt marginal BMPs that would not have been adopted without the program. Thus, it is conceivable that EQIP participation could be estimated as having a negative impact on the profitability of adopting BMPs in some cases, particularly in the presence of competing goals for the farmer, such

as economic profit versus conservation, where the EQIP incentive enticed farmers to adopt for conservation purposes.

An issue associated with using *EQIP* in this model is that it is endogenous—EQIP funding and its perceived impact on farm profitability are simultaneously determined. To test for endogeneity, we applied the Hausman test (Hausman 1978). A probit model with EQIP participation as the dependent variable was run with all of the variables included in the profitability model plus *CASH* and *STREAM*, both of which were significant at the  $P \leq 0.05$  level in the *EQIP* probit model reported earlier. The residual from the probit model was included in the profitability model to check for endogeneity and was found to be significant at  $P \leq 0.05$ , indicating the presence of endogeneity. We thus used the predicted *EQIP* value from the endogeneity-test model as an instrumental variable in the profitability model rather than the actual discrete variable for *EQIP*. All statistical analyses for both the probit and the profitability model were conducted using Stata software.

## Results and Discussion

Table 1 provides details on the eighteen NRCS EQIP-eligible BMPs used in the analyses and Table 2 shows descriptive statistics of the variables chosen for the study. Although farm size varied greatly (average of 660 acres), the average acreage of land used in crawfish production was 211 acres. For leased land, cash leases (33 percent) were more than twice as common as share leases (16 percent). The rest of the producers (51 percent) owned the crawfish land. Nearly equal percentages of crawfish farmers practiced double-cropping (28 percent) and rotation with other crops (31 percent). The percentage of farmers holding a college degree was 29 percent. Most did not hold off-farm jobs (57 percent).

Table 3 shows percentages of responding farmers who adopted each BMP and the reasons given for adoption. BMPs with the highest rate of adoption were irrigation water management (79 percent), irrigation land leveling (75 percent), and nutrient management (57 percent) while irrigation storage reservoirs (7 percent), riparian forest buffers (4 percent), streambank and shoreline protection (3 percent), and tree/shrub establishment (7 percent) had the lowest rate of adoption.

**Table 1. Description of Best Management Practices Used in Crawfish Production**

Best Management Practice	Description
Conservation cover	Establishing and maintaining permanent vegetative cover. Helps in improving air, water, and soil quality. Reduces soil erosion.
Critical area planting	Establishment of permanent vegetation on sites having high erosion rates or conditions that prevent establishment of vegetation with normal practices.
Field border	Permanent vegetation strip established at edge/perimeter of field. Reduces soil erosion, improves soil and water quality, and increases carbon storage.
Grade stabilization structure	A structure used to control the slope in natural or artificial channels.
Filter strip	Strips of close-growing vegetation planted around fields and along drainage ways and water bodies. Reduces sediment, organic material, nutrients, and chemicals carried in run-off.
Grassed waterway	Natural or constructed channel shaped or graded to required dimensions and established with suitable vegetation.
Irrigation water management	Process of controlling irrigation water volume, frequency, and application rate for forage and crawfish in a planned, efficient manner.
Irrigation land leveling	Reshaping the irrigated land surface to planned grades.
Irrigation storage reservoir	Irrigation water storage structure made by constructing a dam, embankment, or pit. Holds water in storage until used for irrigation.
Irrigation regulating reservoir	Small storage reservoir constructed to regulate irrigation water supply. Designed primarily for flow control or to store water for a few hours or days. Does not generally include detailed design criteria.
Irrigation system tailwater recovery	Planned irrigation system with facilities installed for collection, storage, and transportation of irrigation tailwater and/or rainfall run-off for reuse.
Irrigation water conveyance pipeline	Pipeline installed in an irrigation system to prevent erosion, loss of water quality, or damage to land.
Nutrient management	Managing the amount, source, placement, form, and timing of application of plant nutrients and soil amendments.
Pumping plant	Used to transfer water for a conservation need.
Range planting	Perennial vegetation establishment (grasses, forbs, legumes, shrubs, trees).
Riparian forest buffer	Area of trees and/or shrubs located adjacent to and uphill from a water body.
Streambank and shoreline protection	Treatment used to stabilize and protect banks of water bodies.
Tree/shrub establishment	Establishment of woody plants by planting seedlings or cuttings, direct seeding, or natural regeneration.



Most of the farmers had adopted BMPs primarily because it led to increased profit (37 percent), was good for long-run land productivity (24 percent), or was good for the environment (21 percent). The other two adoption reasons were chosen much less often; 5 percent of farmers said they had been encouraged or required to adopt and 2 percent said the practices had already been established. Most of the farmers were primarily profit-oriented in deciding to adopt BMPs, though environmental concerns also influenced their decisions (37 percent versus 21 percent).

Table 4 shows the percentage of farmers who were participants in the EQIP for each BMP. For the group as a whole, 57 percent had received EQIP support. Most had received it for irrigation land leveling. Three other BMPs were associated with EQIP participation: grade stabilization structures, irrigation water management, and irrigation water conveyances via a pipeline. These results suggest that farmers are more likely to participate in the EQIP when they are implementing irrigation-related practices and less likely to do so for practices involving vegetative cover. This is not surprising since irrigation systems require

a substantial capital investment. The decision also is influenced by a farmer's perception of BMPs' contribution to overall farm productivity: adoption of the four most frequently adopted BMPs using EQIP funds was primarily for productivity reasons with "It leads to increased profit" and "It's good for long-run land productivity" combining to represent 72 percent or more of the motivation for adoption of those practices. The results for the other two practices that had multiple adopters via the EQIP, nutrient management and pumping plants, were similar. Five of the BMPs had no association with EQIP funds and mostly also had a low rate of adoption in general.

Table 5 presents the probit results for factors affecting farmer EQIP participation. The results suggest that farm size, cash leasing of land, double-cropping, rotation of crops, a four-year college degree, and the presence of a stream flowing through the farm significantly affected farmers' EQIP participation. The magnitude of these impacts, as shown by the marginal effects, is striking. Each additional 1,000 acres of land in the crawfish operation increased the probability of EQIP participation by 0.21, suggesting that

**Table 2. Means of Independent Variables Other Than BMPs Used in the Probit and Interval Regression Models**

Independent Variable	Description	Mean	Standard Deviation
<i>ACRES</i>	Continuous: Number of acres on the farm divided by 1,000	0.66	0.84
<i>OWN</i>	Dummy: Producer owns all land used to raise crawfish = 1	0.37	0.49
<i>CASH</i>	Dummy: Producer rents land used to raise crawfish under a cash lease = 1	0.33	0.47
<i>SHARE</i>	Dummy: Producer rents land used to raise crawfish land under a share lease = 1	0.16	0.37
<i>DOUBLECROP</i>	Continuous: Portion of crawfish land double-cropped with rice	0.28	0.45
<i>ROTATION</i>	Continuous: Portion of crawfish land rotated with rice and/or soybeans	0.31	0.46
<i>AGE</i>	Continuous: Farmer's age. 1: $\leq 30$ ; 2: 31–45; 3: 46–60; 4: 61–75; 5: $\geq 76$	3.07	0.67
<i>COLLEGE</i>	Dummy: Producer holds a college bachelor's degree or more = 1	0.29	0.46
<i>CRAWFISHINCOME</i>	Continuous: Percent of farm income from crawfish operation. 1: 1–19 percent; 2: 20–39 percent; 3: 40–59 percent; 4: 60–79 percent; 5: 80–100 percent	2.15	1.49
<i>OFF-FARM JOB</i>	Dummy: Producer holds an off-farm job = 1	0.43	0.50
<i>STREAM</i>	Dummy: Farmer response. "A stream/river runs through my farm" = 1	0.40	0.49
<i>BMPs<math>\geq 5</math></i>	Dummy: Farmer adopted five or more BMPs = 1	0.58	0.50
<i>OTHER6BMPs</i>	Dummy: Farmer adopted one or more of the six BMPs adopted by less than ten producers.	0.26	0.44

**Table 3. Analysis of Reasons for Adopting Best Management Practices**

Best Management Practice	Percent Who Adopted	Reasons for Adopting (percent of adopters)					
		Leads to Increased Profit	Good for the Environment	Have Been Encouraged or Required to Do So	Good for Long-run Land Productivity	Established by the Landowner or Another Tenant	Checking All Five Reasons for Adoption
Conservation cover	54	37	16	3	26	0	18
Critical area planting	47	18	18	6	44	0	15
Field border	40	14	29	7	39	4	7
Grade stabilization structure	39	11	11	4	61	4	11
Filter strips	23	18	29	6	41	0	6
Grassed waterway	17	8	42	8	17	8	17
Irrigation water management	79	64	5	5	11	0	15
Irrigation land leveling	75	55	2	5	25	0	13
Irrigation storage reservoir	7	80	0	0	20	0	0
Irrigation regulating reservoir	11	75	13	0	13	0	0
Irrigation system tailwater recovery	14	60	20	0	20	0	0
Irrigation water conveyance pipeline	61	50	2	2	25	2	18
Nutrient management	57	53	10	5	20	3	10
Pumping plant	24	75	0	13	13	0	0
Range planting	10	29	14	14	43	0	0
Riparian forest buffer	4	0	100	0	0	0	0
Streambank and shoreline protection	3	0	50	0	0	0	50
Tree/shrub establishment	7	20	20	20	20	20	0
Mean	32	37	21	5	24	2	10

**Table 4. Number of EQIP Participants for each Best Management Practice in 67 Total Responses**

Best Management Practice	Number of EQIP Participants
Conservation cover	1
Critical area planting	1
Field border	0
Filter strips	1
Grade stabilization structure	17
Grassed waterway	1
Irrigation water management	14
Irrigation land leveling	24
Irrigation storage reservoir	1
Irrigation regulating reservoir	0
Irrigation system tailwater recovery	1
Irrigation water conveyance pipeline	14
Nutrient management	7
Pumping plant	3
Range planting	0
Riparian forest buffer	0
Streambank and shoreline protection	0
Tree/shrub establishment	1

Note: Total cost-share participation percentage is 57 percent (i.e., 38/67).

operators of larger farms are greater users of the EQIP. Operating under a cash lease system lowered the probability of EQIP participation by 0.43. This result is consistent with the negative association of cash leases with BMP adoption found by Nyaupane and Gillespie (2011). Though EQIP participation reduces the capital outlay associated with BMP adoption, some investment is still required so renters would be less inclined to apply.

Farmers who used double-cropping and crop-rotation systems were substantially more likely to participate in the EQIP; use of a double-crop system increased the probability by 0.45 and use of crop rotation increased it by 0.67. Double-cropping and crop-rotation systems use land more intensively, which increases the need for BMPs and, thus, for EQIP funds. In addition, the benefits of the BMPs are spread over multiple crops.

*COLLEGE* increased the probability of EQIP participation by 0.38. As found by McLean-Meynsse, Hui, and Joseph (1994), education increases awareness of government programs. *STREAM* raised the probability of EQIP participation by 0.41. The pseudo R-square was

0.48, suggesting a relatively strong goodness-of-fit for cross-sectional data.

Table 6 shows the results of interval regressions for the perceived economic impacts of BMP adoption. Those considered to have significantly increased the profitability of the farm were conservation cover, nutrient management, and pumping plants. Adopters of those three practices had adopted them primarily to increase profit (see Table 3). On the other hand, adoption of filter strips was perceived as negatively impacting profitability. As shown in Table 3 and unlike most of the BMPs, filter strips were most often adopted because they

were viewed as good for long-run land productivity, followed by their being good for the environment. Increased profitability ranked third. Most of the farmers who did not implement filter strips said that the practice did not apply to their farms (Nyaupane and Gillespie 2011). So it appears that, in spite of adoption of filter strips by 23 percent of the crawfish farmers, filter strips were not viewed as profitable or applicable.

The magnitude of the perceived effects of BMPs on profitability can be determined directly from the  $\beta$  coefficients. Conservation cover, nutrient management, and pumping plant adoption increased

**Table 5. Probit Runs for the Factors that Affect EQIP Participation**

Variable	Coefficient (robust standard error)	Marginal Effect (standard error)
<i>CONSTANT</i>	-2.42** (1.18)	
<i>ACRES</i>	0.52* (0.30)	0.21* (0.12)
<i>CASH</i>	-1.13** (0.48)	-0.43*** (0.16)
<i>SHARE</i>	0.63 (0.58)	0.24 (0.20)
<i>DOUBLECROP</i>	1.33** (0.55)	0.45*** (0.14)
<i>ROTATION</i>	2.28*** (0.54)	0.67*** (0.08)
<i>AGE</i>	0.25 (0.30)	0.10 (0.12)
<i>COLLEGE</i>	1.04** (0.44)	0.38*** (0.14)
<i>CRAWFISHINCOME</i>	-0.09 (0.13)	-0.04 (0.05)
<i>OFF-FARM JOB</i>	0.40 (0.51)	0.16 (0.19)
<i>STREAM</i>	1.09*** (0.42)	0.41*** (0.14)
Observations	67	
Pseudo R-square	0.48	
Log pseudo-likelihood	-24.10	
Wald chi-square	45.86***	

Note: \*, \*\*, and \*\*\* denote statistical significance at the 0.10, 0.05, and 0.01 levels, respectively.

**Table 6. Interval Regression Results for the Economic Impact from BMP Adoption**

Variable	Coefficient	Robust Standard Error
<i>CONSTANT</i>	-9.48	(4.89) *
Conservation cover	12.76	(3.71) ***
Critical area planting	-0.29	(3.73)
Field border	0.10	(3.07)
Grade stabilization structure	-2.32	(2.92)
Filter strips	-9.83	(3.86) **
Grassed waterway	-0.65	(4.81)
Irrigation water management	2.84	(3.48)
Irrigation land leveling	-3.19	(2.61)
Irrigation system tailwater recovery	4.11	(3.40)
Irrigation water conveyance pipeline	3.16	(2.96)
Nutrient management	7.90	(2.82) ***
Pumping plant	7.03	(4.03) **
<i>OTHER6BMPS</i>	-0.45	(3.91)
<i>BMPS</i> $\geq 5$	-0.57	(3.90)
<i>OWN</i>	5.82	(2.91) **
<i>DOUB-ROTATION</i>	13.67	(4.35) ***
<i>COLLEGE</i>	3.30	(3.74)
<i>PR-EQIP</i> (predicted EQIP value)	-15.92	(6.69) **
LnSigma	1.98	(4.89) ***
Sigma	7.27	(1.03)
Observations	55	
Wald chi-square	89.56***	

Note: \*, \*\*, and \*\*\* denote statistical significance at the 0.10, 0.05, and 0.01 levels, respectively.

the perceived profitability associated with BMP adoption by 12.76, 7.90, and 7.02 percentage points, respectively. Adoption of filter strips reduced the perceived profitability associated with BMP adoption by 9.83 percentage points.

Ownership of the land associated with crawfish production increased the perception of profitability associated with BMPs, which is consistent with the fact that many of the long-run benefits of BMPs accrue to the owner rather than to renters. Double-cropping and crop rotation were associated with farmers' perceptions that the BMPs they had implemented were profitable, which suggests that crawfish and other crops in the system such as rice are technically complementary in BMP adoption. This finding supports the results of Nyaupane and Gillespie (2011), which showed that double-crop and crop-rotation producers are more likely to adopt BMPs.

Participation in the EQIP negatively influenced farmers' perceptions of the impact of adopted BMPs on farm profits, perhaps because EQIP funds encouraged adoption of BMPs that would not otherwise have been adopted if farm profitability was the sole driver. On the surface, this may seem inconsistent with other study results that showed that EQIP-adopted BMPs were adopted primarily to increase profit and/or productivity. The results, however, suggest that farmers who accessed the EQIP to adopt believed that the combination of BMPs they used had impacted profit less positively than farmers who did not rely on EQIP funds irrespective of the BMPs adopted. The negative sign for EQIP occurred consistently in this study, both prior to using the instrumental variable for EQIP and with the correction for endogeneity. It is important to note that the wording of the question analyzed was in the context of *perceived* profitability associated with BMPs; the farmers' responses may not have accounted for actual profitability given that cost-sharing had reduced the amount of capital they had to invest.

## Conclusions

This study examined adoption of BMPs in the crawfish industry to identify the primary drivers of BMP adoption and EQIP participation and to assess farmers' perceptions of the impact the practices had on their operations. The top reasons for BMP adoption were farmers' perceptions that BMPs increased their profits and the long-run productivity

of their land. Few farmers (5 percent) adopted because they had been required or encouraged to do so and only 2 percent of the participating farmers reported that BMPs were already in place when they began to operate their farms. Our study adds further support for the importance of farm profitability in BMP adoption as identified by Nyaupane and Gillespie's (2011) analysis of crawfish production. Their results showed that a farmer's decision not to adopt BMPs was rarely based on a belief that adoption would reduce the farm's profit. Furthermore, we found that farmers who adopted three particular BMPs—conservation cover, nutrient management, and pumping plants—concluded that BMP adoption had increased their profits. Taken together, these results suggest that many of the BMPs are perceived as economically advantageous to crawfish farmers. The consistent message is that producers adopt BMPs primarily for financial reasons while environmental benefits and long-run productivity are also important.

Considering the importance of farm profitability in BMP adoption, continued and/or enhanced economic incentives will be important in moving toward greater BMP adoption. EQIP participation's negative impact on perceptions of the profitability of adopting BMPs supports this conclusion: EQIP funding allows and/or encourages farmers to adopt BMPs that they otherwise would not adopt because they perceive them as unprofitable without cost-sharing. For these "marginal" practices, the goals of increasing long-run land productivity, sustainability, and environmental benefit are likely important enough to farmers that they want to implement them if made affordable. It is perhaps not coincidental that two of the three BMPs that were perceived as having increased farm profitability in the impact analysis (conservation cover and pumping plants) had relatively low rates of EQIP participation—farmers adopting those BMPs had largely done so without EQIP funds. Furthermore, only seven producers had used EQIP support to adopt nutrient management, which had a relatively high adoption rate. These results underscore the importance of programs such as the EQIP in encouraging adoption of sustainable agricultural practices that otherwise might not be adopted. Future studies could delve further into farmers' motivations for participating in the EQIP to further clarify the program's effectiveness. We would like to see whether the EQIP-profitability results hold for other agricultural industries.

Double-cropping and crop rotation (usually with rice) are common in the crawfish industry, and these systems have several implications for BMP adoption. While Nyaupane and Gillespie (2011) found that the impacts of double-cropping and crop rotation in crawfish production varied with the BMPs adopted, double-cropping consistently increased the total number of BMPs adopted. Our analysis of the impacts of BMPs on profitability shows that farmers perceive BMP profitability as improved when using double-cropping or rotational systems relative to single-crop crawfish production, suggesting technical complementarity between crawfish and rice in BMP adoption. Furthermore, we find that crawfish farmers who use double-cropping or crop rotation are more likely to participate in the EQIP. The combination of these two results suggests that double-cropping positively impacts both BMP adoption and use of EQIP funds to implement the practices plus increases the profitability of BMPs. When we examine the top four crawfish BMPs for which the EQIP is used, all are also particularly useful for rice production since they address irrigation and land slope issues and involve substantial initial capital outlays. Our conclusion is that double-cropping and crop-rotation systems are conducive to BMP adoption and EQIP participation, primarily for reasons of increased BMP profitability.

The present and past studies have found land rental to be a significant hindrance to BMP adoption, a concern for agents working to encourage adoption since a relatively high percentage of crawfish land is leased. We found that land ownership was associated with the perception that BMPs improve farm profitability. Furthermore, Nyaupane and Gillespie (2011) found that cash lessors less often adopted five of twelve BMPs in that study and that share lessors less often adopted one of twelve BMPs. Considering that very few respondents in this study were working land with pre-established BMPs, we conclude that BMPs are less likely to be established on rented land under any considered circumstance. Our results further show that cash leases reduce the probability of EQIP participation by 0.43. Today's prevalence of leased land under agricultural cultivation thus presents some significant challenges in encouraging BMP adoption. Given ongoing trends toward increasingly large farms and the lease structure common to such farms, we can expect the challenge to grow in the foreseeable future.

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