Transaction Costs of Environmental Policies and Returns to Scale: The Case of Comprehensive Nutrient Management Plans

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Abstract

Environmental policies are considered to be more onerous for small businesses than for large ones due to increasing returns to scale of abatement technologies as well as transaction costs. Comprehensive nutrient management plans (CNMPs) are being promoted to reduce excess nutrient applications on livestock farms in order to improve water quality. Development of CNMPs has been shown to exhibit increasing returns to scale but these costs did not include farmer time and the estimates were made when the program was relatively new. Data from a farmer survey as well as interviews with government staff are used to characterize the magnitude and determinants of the transaction costs of CNMP development in the Midwest. The analyses confirm that transaction costs borne by farmers exhibit economies of scale.

Key Words Economies of scale, environmental policy, manure, transaction costs

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Introduction

Livestock operations can contribute to poor surface water quality in a number of ways. Excess nutrients, particularly nitrogen and phosphorous, can cause eutrophication of lakes and streams and excess nitrogen has been linked to hypoxia in the Gulf of Mexico. Deleterious effects on aquatic life and even fish kills have been experienced. In addition, waste from livestock production systems contains microorganisms that can affect human health.

In the Unified National Strategy for Animal Feeding Operations (USDA and USEPA 1999) there was an expectation that all animal feeding operations (AFOs) would develop comprehensive nutrient management plans (CNMPs) within ten years. All permitted livestock operations will be required to have a CNMP. The goals of a nutrient management plan (one component of a CNMP) are to supply nutrients to crops at agronomic rates and thus to reduce water pollution. Components of a plan may include soil testing, manure testing, manure nutrient crediting and a manure spreading plan.

Originally, only government agency staff such as Natural Resource Conservation Service (NRCS) personnel could develop a plan but later changes allowed third party technical service providers (TSPs) or individual farmers with appropriate training to write plans as well. These plans are verified by NRCS staff. Technical assistance consists of four steps: 1) develop and evaluate alternatives for the farm, 2) design practices, 3) assist with implementation, and 4) follow up with the producer (USDA-NRCS 2003).

A recent Wisconsin study (Shepard 2005) found that dairy farmers with a nutrient management plan applied less nitrogen and phosphorous than farmers who didn't have plans but some still overapplied nutrients. Nutrient application rates were similar for

those with private plans versus those by government agencies. In addition to a nutrient management plan, implementation and maintenance are necessary to obtain improvements in water quality. Anecdotal evidence is that plans often are put on a shelf and not followed, or are followed for a time and then abandoned. The fact that even farmers with nutrient management plans over-applied nitrogen and phosphorous could mean that they disregarded the plans or that they were unable to properly implement them, for example by not being able to correctly credit manure nutrients.

In addition, CNMPs have expanded as far as their use. The Environmental Quality Incentives Program (EQIP), a program to fund environmental improvements on working lands, requires that participants with livestock have a CNMP. Some bankers and insurers, to limit liability, also require a CNMP in order for livestock farmers to obtain loans or insurance (Glenn Davis, personal communication).

Transaction Costs Associated with CNMPs

A number of transaction cost issues arise with respect to development and implementation of CNMPs. There are numerous definitions of transaction costs. A very narrow definition was used by Demsetz (1968, p. 35), "Transaction cost may be defined as the cost of exchanging ownership titles" while Gordon (1994) defines transaction costs as the expenses of organizing and participating in a market or implementing a government policy. This definition is in line with other authors that treat transaction costs and administrative costs as essentially interchangeable terms (McCann et al. 2005) and is the way the term is used in this paper.

As part of an evaluation of the CNMP program, costs associated with the development and implementation of CNMPs were estimated by USDA-NRCS (2003).

From information in the 1997 Census of Agriculture, USDA-NRCS (2003) estimated that 257,201 operations potentially needed a CNMP. Total costs over the ten year period were estimated to be $19.5 billion, of which development or technical assistance costs were 2.1 billion. Such costs could be considered to be transaction costs associated with the policy (McCann et al. 2005). It should be noted that implementation costs would generally be shared by the taxpayers and the farmers via cost-share programs. Development costs borne by the farmers in terms of opportunity cost were not estimated so both transaction costs and total costs were underestimated. The element with the highest implementation costs, waste storage and handling, also had the highest development costs (USDA-NRCS 2003), which is similar to the positive relationship between abatement costs and transaction costs found by McCann and Easter (2000) for other NRCS programs. The costs associated with CNMP's varied by livestock type, size of operation, and production region. Fattened cattle had a high total implementation cost ($18,167) but low per animal unit cost ($14/AU). Development costs were less variable than implementation costs "as there is a practical minimum cost for developing a CNMP" (p. 8). Pasture operations were the lowest (73 hours on average) while swine operations were the highest (200 hours). The average number of hours across all three size categories to develop a plan was 149 hours with an average of 146 for small operations and 170 for large operations. There may also be lengthy delays, and delay in obtaining the benefits from a transaction results in decreased utility or profits (Spulber 1989). In this situation, delays may result in decreased water quality.

Another issue is that costs of developing CNMPs may decrease over time. According to McCann et al. (2005), transaction costs associated with environmental

policies may decrease over time due to learning by doing. A consulting firm that prepares CNMPs will develop expertise and experience over time that can be applied to new CNMPs, thus decreasing the time required for plan development. Costs may also decrease due to refinements in procedures

While not noted in the evaluation by USDA-NRCS, there would also be transaction costs associated with farmers implementing the CNMP over time. CNMPs are difficult to prepare and difficult for farmers to implement correctly which is why NRCS staff and others indicate that CNMPs are often ignored after they are prepared. Rogers (1995) indicates that adoption and diffusion occur more rapidly with innovations that are easily understood and used. This could be due to the fact that information about simple innovations is obtained more easily and cheaply than the information regarding complex innovations (McCann, Nowak and Nunez 2005) and is thus related to transaction costs. In addition, uncertainty is also related to reduced adoption rates and obtaining information to reduce uncertainty is costly. Therefore, farmer transaction costs associated with developing and implementing CNMPs could be underestimated if only the time spent collecting records and discussing the operation with NRCS staff is measured.

Technology affects and is affected by market structure. According to Martin (1993) economies of scale in production, i.e. decreasing average costs as output increases, may be a function of technology. Fixed costs and minimum efficient scale can result in barriers to entry in industries (Martin 1993) and it is recognized that it is very difficult for new entrants to farming to become established. Economies of scale in the production of pork and chicken have resulted in cost advantages for large production

facilities and are related to the rise of contracting in these industries (Martinez and Zering 2004). Spulber (1989) indicates that fixed transaction costs imply non-convexities in transaction production functions and scale economies. From the CNMP program evaluation, it is apparent that there are fixed costs and economies of scale in both the development of plans and their implementation. In other words, both transaction costs and abatement costs exhibit economies of scale, in addition to the well-known economies of scale involved with production costs. Therefore, environmental policies that are uniformly applied across farm sizes may disadvantage smaller farmers since these costs are relatively more important for them.

Small farmers also differ from larger farmers in that they often have off-farm employment that restricts both the number of hours that they can allocate to manure management and the times when they are able to carry out manure management activities. Given that a CNMP is required for EQIP participation, these higher transaction costs may limit participation in that program as well. McCann and Nunez (2004) found that EQIP participation was lower for smaller farmers. Lower cost EQIP projects may thus be eliminated since the farmers that have the highest implementation costs will be more likely to apply for the program and these projects may or may not have higher benefit/cost ratios than smaller projects. Part-time farmers would also have problems meeting with government staff during normal working hours. Mike Duffy (Iowa State Ext. Economist) found that 37% of Iowa farmers worked more than 200 hours off the farm, and 43% of Missouri farmers worked that much.

Model

The USDA study on the CNMP program showed that there are economies of scale associated with both abatement costs and transaction costs, in part due to fixed costs. More formally, a measure of economies of scale of production is the function coefficient which is equal to average cost divided by marginal cost:

$$FC = AC/MC \quad (1)$$

If the function coefficient is less than one, the function exhibits increasing returns to scale, if it equals one, there are constant returns to scale, and if it is greater than one there are increasing returns to scale. If there are fixed costs associated with abatement (FC_A) and transaction costs (FC_T), the effects of fixed costs on returns to scale associated with production (FC_P) will be compounded. Total costs are the sum of various fixed costs plus variable costs (cq). Marginal costs are the derivative of total costs taken with respect to q. Average costs are total costs divided by q.

$$TC = FC_P + FC_A + FC_T + cq \quad (2)$$

$$MC = c \quad (3)$$

$$AC = FC_P/q + FC_A/q + FC_T/q + c \quad (4)$$

This implies that average costs will be higher when these fixed costs are included in the analysis compared to the case where only fixed costs of production are considered. This implies that the function coefficient and thus economies of scale will also be greater.

$$AC_P < AC_{P,A} < AC_{P,A,T} \quad (5)$$

In order to examine the magnitude of transaction costs associated with the development of CNMPs, a survey of livestock producers in Missouri and Iowa was conducted in the spring of 2006.

Data Collection

A preliminary survey was sent out to 100 individual livestock farmers in Missouri. The results of these surveys were used to improve upon the final survey. The final questionnaire was sent out to 3,000 randomly selected livestock farmers in Iowa and Missouri. The eight-page questionnaire included a variety of questions regarding their farming system, participation in government programs, manure management practices, personal characteristics, and environmental attitudes. Formats included fill in the blank, Liekert scale, multiple choice, and open-ended questions.

The methodology followed Dillman's (2000) procedures. The survey was first sent out to the randomly selected individuals along with a cover letter explaining the purpose of the survey, giving them directions on how to fill out the survey and reminding them that their participation was strictly voluntarily. The survey also included a postage paid return envelope for their convenience and a form to fill out to enter into a drawing to win a $200 gift certificate as an incentive. The second mailing was a post-card reminder. The third and final mailing contained the same materials as the first mailing with a modified cover letter. The third wave was sent to only those who had not yet responded, either with a completed questionnaire, a refusal, or an indication that the survey was not appropriate since they had retired or no longer had livestock. There were 1030 completed questionnaires returned before the cut-off date.

Results and Discussion

One of the questions asked whether the farmer had a comprehensive nutrient management plan (CNMP) that was approved by NRCS. Only the surveys with a CNMP were included in this analysis unless otherwise indicated. Fifty-nine people indicated that they used a technical service provider (TSP) to develop their CNMP, three indicated they had worked with both a TSP and NRCS, 118 indicated that they had worked with NRCS, one indicated they had prepared it themselves and with NRCS, and nine indicated they had prepared it themselves. Sixteen farmers did not respond to this question and nine of those did not indicate the year it was prepared so this may indicate they did not have a true CNMP. Due to the missing data, these were deleted from subsequent analyses.

Summary statistics for variables and observations used in the transaction cost regressions are shown in Table 1. The CNMP had been prepared four years ago on average. The average number of animal units was 1061 which is above the cut-off for designation as a CAFO. Average number of acres farmed was 713 acres which is greater than the average for the survey as a whole of 587 acres. Of these farmers, 52 percent had a solid manure system in which they used a loader or scraped manure and applied it with a spreader, 23 percent had a liquid management system such as a pit or lagoon and 25 percent had a combination of these two systems. Over a quarter of these farmers had no off-farm income indicating that they were full-time farmers and their spouses did not work. The next most common level of off-farm income was $25,000-49,000 representing one quarter of households. Only small percentages of farmers had education levels less than high school or more than a B.S. degree. The most common educational levels were a high school degree (44 percent) and some college (33 percent).

Transaction costs associated with CNMP development may consist of time spent by farmers and NRCS staff. In the case where a TSP is involved this becomes an out of pocket cost rather than NRCS staff time, although NRCS is still involved with verifying and approving TSP-prepared CNMPs. One of the questions asked for the cost of the CNMP if they had worked with a TSP. The average TSP cost indicated was $450. There were only 43 observations available for the analysis so few explanatory variables were included in the OLS regression. These included: 1) the number of years ago the CNMP was prepared which could test whether costs decrease as people become more familiar with the process, 2) the total number of animal units on the farm, and 3) dummy variables for type of manure management system with the liquid system being the base. The dependent variable was average cost of a TSP so the cost indicated in the survey was divided by the number of animal units[1]. Regression results are shown in Table 2. Given the small number of observations, it is not surprising that no explanatory variables were statistically significant, however, the total animal units approached significance and the coefficient was negative which would indicate there are economies of scale in CNMP development. The positive and significant intercept may indicate the presence of fixed costs. The dummy variable for both solid and liquid manure management systems also approached significance and was positive which would expected since this type of system is more complicated.

Two questions on the survey were designed to examine the transaction costs incurred by farmers in CNMP development. The first question asked how many hours

[1] Animal unit is a measure that is used to convert numbers of animals of various species to one consistent measure so for example, one animal unit is equal to one dry beef cow, 10 swine less than 55 pounds, and 100 chickens.

they spent with an NRCS staff person or their TSP provider. The second question asked how many hours they spent on "reading, paperwork, and pulling together information for the CNMP" which would represent the farmer's information costs. If a respondent indicated days, a six-hour day was assumed (Glenn Davis, personal communication). The mean number of hours reported for meetings with staff was 7.62 (n=172). This is fairly low relative to the average hours spent by NRCS staff developing CNMPs, 149, reported by USDA (USDA-NRCS 2003). This is because most of the staff time is spent designing the CNMP once information on the operation is obtained. The mean number of hours reported for information gathering and processing was 9.23 (n=166). For those who answered both questions, the mean number of hours spent on both activities was 16.69. This total was then divided by the number of animal units to obtain the average number of hours spent on CNMP development.

Table 3 shows the regression that was run with the same variables as the average TSP cost variable. Animal units is highly significant but the dummy variable indicating both solid and liquid manure management systems is still not significant. Another regression model (Table 4) included: 1) the acres farmed since larger acreages may allow more flexibility in manure management, 2) whether the CNMP was prepared by a TSP, NRCS (the base category), or the farmer, 3) off-farm income category since their opportunity cost may be higher (10,000-25,000 as the base), and 4) level of education since higher educational levels may enable them to process information more efficiently (high school graduate was the base). Animal units was the only significant variable, which again indicates that there are economies of scale involved with CNMP development costs borne by farmers.

The TSP cost, as with the USDA study, shows that non-farmer CNMP development costs exhibit economies of scale. The survey results may underestimate the true TSP cost if the cost was cost-shared by NRCS or another organization and farmers only indicated their own costs. The analysis of hours spent by farmers shows that the costs based only on NRCS staff time underestimate the true transaction costs involved with CNMP development by about 10 percent. However, the average time spent was only about two working days which does not seem to be particularly onerous. As McCann et al. (2005) point out however, information costs are only one category of transaction costs so this is also an underestimate of farmer transaction costs. Both analyses provide strong support for the idea that there are economies of scale involved with CNMP development. The costs measured in this study are for farmers who actually have a CNMP in place. Those who may have been dissuaded by the costs are not in this data set. The questionnaire did not ask for reasons why the farmer did not have a CNMP[2].

An analysis of the responses to a question regarding reasons for not applying to the USDA Environmental Quality Incentives Program (EQIP) may be relevant. Farmers in the full data set (n=1030) gave a number of reasons for not applying. These answers were grouped into several broad categories. The most common response (31 respondents) was just "not needed" but others added that it wasn't needed because it didn't fit the operation (3), the operation was too small (8) or there were no environmental issues (2) for a total of 44. Another group indicated that they weren't interested, didn't care, or that there was no benefit to them (10 respondents) which may

[2] A separate probit regression with data for farmers with accumulating manure (rather than pasture) found that species, number of animal units, and the extent to which NRCS affected their farm decisions significantly affected whether they had a CNMP in place.

be related to the "not needed" category. The second most common response category related to perceived transaction costs of the program, with 18 farmers indicating there were too many hoops, red tape or paperwork. Other reasons given were that people had already implemented practices, they weren't aware of the program, they didn't want to be involved with government programs in general, the probability of being accepted into the program was too low, costs to farmers were too high, the practices that would qualify were unnecessarily expensive, or they were not eligible.

Implications

The fact that fixed costs associated with environmental policies can increase the optimal scale of livestock production facilities has important consequences for policy and for research. Recently, EPA considered lowering the size threshold for confined animal feeding operations (CAFOs) which are regulated as point sources of pollution. Ultimately, the final regulations kept the threshold at the same size (1000 animal units) which may be due to consideration of the disproportionate burden this would have placed on smaller farmers. On the other hand, smaller farmers may contribute significantly to environmental damage such as water pollution. Smith et al. (2004) found that unconfined operations contributed more phosphorous to the Mississippi River than confined operations. Voluntary programs thus become very important if we are to improve water quality.

Voluntary programs that provide technical assistance and cost-sharing may also place a disproportionate burden on smaller farms due to the relatively more important transaction costs associated with learning about the programs, interacting with NRCS staff or technical service providers, collecting information needed to fill out applications

or develop CNMPs, completing paperwork, and keeping records. This is particularly difficult if programs change often, as they have in the recent past, or if the forms and requirements differ between programs.

Some efforts are underway to reduce these problems. There are projects that are designed to develop templates for CNMPs, thus reducing the time required to create them (Missouri Nutrient Management Plan Document Generator) and these spreadsheets and forms are being shared across states, although this may not be appropriate in some cases (John Lory, personal communication). Spulber (1989) indicates that standard contracts can decrease transaction costs but farming systems, and the hydrology of farms and watersheds are complex. Dan Lawson, in a presentation to a regional Soil and Water Conservation Society meeting, discussed the emphasis in the agency on streamlining the NRCS manual, procedures, and forms, as well as standardizing templates to maximize the performance of existing programs. For example, the producer self-assessment tool in the Conservation Security Program (CSP) may be expanded to other programs in the future. These actions may increase efficiency in general and also have the benefit of reducing the burden on smaller farmers.

However, there may still be a need for an alternative to the CNMP that is more appropriate for small farmers. As indicated previously, CNMPs are increasingly being required by bankers and insurers so it is less voluntary and more a necessary part of doing business. In some states, such as Missouri, the CNMP is required as part of a permit to operate, even for some farms that do not meet the definition of a CAFO. Decreasing transaction costs for small livestock farmers by having a more simple CNMP, a CNMP "light" if you will, can have multiple benefits. It could free up time of NRCS staff,

decrease costs for the farmers, and increase adoption, implementation, and maintenance of nutrient management plans.

Further information on the nature and magnitude of transaction costs incurred by farmers in the development of CNMPs is needed to evaluate the extent of this problem and to examine how the program could be modified. This study did not examine the information and decision costs farmers incur as they implement the plan over time, nor did it account for record-keeping costs. An examination of these issues could help explain why so many CNMPs are not fully implemented.

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Table 1. Summary Statistics for farmers with a CNMP.

Variable	Mean	Range
CNMP prepared by TSP	0.29	0-1
CNMP prepared by NRCS (base)	0.67	0-1
CNMP prepared by farmer	0.04	0-1
Years ago it was prepared	4.08	0-19
Total animal units	1061	25-5600
Acres farmed	714	10-3780
Solid manure system	0.52	0-1
Liquid manure system (base)	0.23	0-1
Both solid and liquid	0.25	0-1
No off farm income	0.29	0-1
$0-9,999 off farm income	0.12	0-1
$10,000-24,999 (base)	0.16	0-1
$25,000-49,999	0.25	0-1
$50,000-99,999	0.13	0-1
> $100,000	0.05	0-1
Less than a high school education	0.04	0-1
High school graduate (base)	0.44	0-1
Some college	0.33	0-1
B.S. degree	0.16	0-1
Graduate degree	0.03	0-1

Table 2. Regression of factors affecting average TSP cost (n=43).

Variable	Coefficient	Standard Error	P-value
Constant	0.557	0.270	0.046
Years ago CNMP prepared	-0.005	0.029	0.847
Total animal units	-0.000	0.000	0.137
Solid manure management system	-0.162	0.305	0.599
Both solid and liquid manure system	0.363	0.251	0.156

R^2 = 0.11, Adjusted R^2 = 0.02, F=1.23.

Table 3. Regression of factors affecting average hours spent on CNMP development by farmers (n=153).

Variable	Coefficient	Standard Error	P-value
Constant	0.040	0.008	0.000
Years ago CNMP prepared	0.000	0.001	0.874
Total animal units	-0.000	0.000	0.000
Solid manure management system	0.005	0.007	0.485
Both solid and liquid manure system	0.012	0.008	0.148

R^2 =0.18, Adjusted R^2 = 0.16, F=8.05

Table 4. Expanded regression of factors affecting average hours spent on CNMP development by farmers.

Variable	Coefficient	Standard Error	P-value
Constant	0.039	0.013	0.002
CNMP prepared by TSP	-0.004	0.007	0.560
CNMP prepared by farmer	-0.008	0.016	0.634
Years ago it was prepared	0.000	0.001	0.871
Total animal units	-0.000	0.000	0.000
Acres farmed	0.000	0.000	0.637
Solid manure system	0.003	0.008	0.671
Both solid and liquid	0.013	0.009	0.159
No off farm income	0.005	0.010	0.730
$0-9,999 off farm income	0.004	0.012	0.730
$25,000-49,999	0.008	0.010	0.416
$50,000-99,999	0.004	0.011	0.740
> $100,000	-0.011	0.015	0.467
Less than a high school education	-0.017	0.016	0.297
Some college	-0.001	0.007	0.881
B.S. degree	0.001	0.009	0.951
Graduate degree	-0.007	0.020	0.732

R^2 =0.21, Adjusted R^2 = 0.11, F=2.20.