Cost-sharing Incentive Programs for Source Water Protection: The Grand River's Rural Water Quality Program

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Abstract

Canadian provinces have become increasingly concerned with possible contamination of water from upstream agricultural activities. Many see watershed-based source protection, so called "source-to-tap" programs, as a means of improving water quality. A key factor in the success of these programs is the extent to which they provide incentives to farmers to undertake actions that ultimately result in a reduction of non-point source pollution. One type of program is cost-sharing whereby farmers are reimbursed for out-of-pocket expenses relating to best management practices which are expected to reduce runoff into water courses. Given increasing reliance on these types of programs, it is necessary from a public policy perspective to identify design features leading to the greatest likelihood of farmer participation. This paper examines Ontario's Rural Water Quality Program for the Grand River using data from the first seven years of its operation, along with data from Agricultural Canada's Farm Census, to model and estimate participation rates. Significantly positive determinants include: the maximum grant available and performance incentives, although both with diminishing returns. Projects with a one-time capital subsidy alone are much less likely to encourage participation than projects that combine a subsidy with a performance incentive.

Introduction

The quality of source water used by municipal water utilities in Canada has increasingly come under scrutiny (Bernard et al., 2000). Since the events in Walkerton in 2000 and North Battleford in 2001, contamination of source water by agricultural activities has been of especial concern. In 2003 the province of Ontario formed two committees to review watershed-based source protection (Implementation Committee Report, 2004). The mandates of these committees were heavily influenced by Justice O'Connor's report from the Walkerton Inquiry (O'Connor, 2002). The Implementation Committee was charged with two tasks: to provide advice on the variety of approaches/levels of responsibilities that could be used to manage risks to source drinking water and on the best methods for funding these protection activities.[1] The Committee recognized the role that could be played by farmers in reducing non-point source pollution from agricultural activities. Amongst its 133 recommendations, the Committee suggested that " … Federal and provincial governments, municipalities, conservation authorities and other relevant groups should work together to ensure their incentive programs enhance and promote source protection and are coordinated, consistent, complementary, and accessible" (Recommendation #128). In particular, the Committee supported the use of cost-sharing approaches to further the goal of watershed management.

Under cost-sharing, farmers are reimbursed by government for some portion of their out-of-pocket expenses when they voluntarily undertake certain actions (either the adoption of identified best management practices or other approved efforts) which are expected to lead to a reduction in the amount of non-point source pollution. The province of Ontario supports the use

[1] These efforts culminated in passage of the Ontario Clean Water Act in 2006 with accompanying regulations issued in 2007 and establishment of local drinking water source protection committees that prepare terms of reference for watersheds in their regions.

of cost-sharing methods and incorporated them in the Nutrient Management Act 2002 – which came into effect in September 2003. The goal of this legislation is to protect source water through the provision of financial assistance to large livestock farmers for the creation and implementation of nutrient management plans that will better manage livestock waste and reduce runoff into water courses. In 2005, the government announced increases in the maximum amount of financial support available (OMAFRA, 2005) in order to encourage farmer participation.

Ontario is not alone in choosing to employ a cost-sharing approach to encourage farmers to alter their behaviour in hopes of having beneficial impacts upon water quality. These programs operate in a number of countries under different names - e.g., agri-environmental payment programs (Cooper and Signorello, 2008) or payments for environmental services (Engel, Pagiola, and Wunder, 2008) - and a wide variety have been in place in the United States for the last few decades (Ribaudo, Horan, and Smith, 1999).[2] While there appears to be agreement in principle on certain aspects of cost-sharing programs, they do differ in their details, such as which particular activities are covered, whether adoption of the project is covered by a fixed payment or performance incentive, and the extent of the costs borne by government agencies, as opposed to the farmer.

Given the increasing reliance by governments upon these types of programs, it is necessary to identify those aspects of a program that would be demonstrated to lead to the greatest success in

[2] Norton, Phipps, and Fletcher (1994) review a number of US programs to illustrate that voluntary cost-sharing programs are much more popular (and, hence successful) than programs that either regulate or tax the use of certain farm inputs.

terms of farmer participation.[3] This paper examines a voluntary cost-sharing program that has already been put into place in Ontario: the Rural Water Quality Program. The program began in the Regional Municipality of Waterloo but has since spread to include the counties of: Wellington, Northumberland, Brant, Dufferin, Oxford, Perth and parts of Halidmand, Halton and Norfolk counties.

This paper examines data from the first seven years of operation of the Rural Water Quality Program (1998-2004). The program is an example of a design-based environmental standard program whereby best management practices are identified and farmers are offered a subsidy to encourage their compliance. By offering the subsidy the regulatory authority attempts to change farmers' behaviour since it pays the farmer some part of the cost of implementation.[4] The contribution of this paper is to examine empirically those factors that help to explain the rate of participation in the program with the goal of being able to identify which factors are most likely to encourage farmers to adopt practices that are considered to lead to improvements in upstream water quality. Given the costs associated with this type of program and the difficulties associated with measuring their benefits, the novel aspect of this paper is an approach and methodology to assist in identifying the magnitude of farmer uptake and responsiveness to changes in program features (such as subsidy rate and the size of the performance incentive) using data that are readily available.

[3] Ultimately, we would like to know the extent to which these programs reduce the amount of pollution that enters upstream water sources, however, this is not directly observable. What we can observe is the number of farms that adopt such best management practices.
[4] Since 93 % of watershed is rural (Farwell, Boyd, and Ryan, 2008), this program is clearly an important component of any overall source water protection plan.

The rest of this paper is organized as follows. A brief literature review of both theory and practice is presented in the next section to facilitate the development of hypotheses to be examined in the empirical section. This is followed by a description of the Rural Water Quality program as managed by the Grand River Conservation Authority (GRCA). A description of the data used in the empirical analysis, along with the results, comes next. The paper concludes with some suggestions and policy implications arising from the results.

Literature Review

Nonpoint-source pollution is an externality that arises when farmers make what are privately optimal decisions relating to choices of on-farm resources and these decisions impose off-farm costs in the form of (water) pollution upon others in society (Braden and Lovejoy, 1990). Models of optimizing farm behaviour assume that farmers consider only their own production costs and not the external pollution (off-farm) costs (Griffin and Bromley, 1982; Norton, Phipps, and Fletcher, 1994; Shortle and Dunn, 1986). Since off-farm pollution does not enter water bodies at well-defined locations, it is very difficult to measure and, therefore, monitor and/or alter such polluting behaviour. While we know why non-point source pollution is likely to occur, our understanding of how to encourage reductions in the level of these externalities is less well developed.

From the perspective of society as a whole, these private farming decisions lead to a misallocation of resources. This can be redressed in a number of ways ranging from outright banning of certain activities and/or quantitative restrictions on the use of certain inputs through to the adoption of economic instruments designed to encourage a reduction in effluents from farms. While economic tools such as emissions charges and permits have been lauded as providing market-like incentives to polluters and resulting in efficient social choices (OECD, 1989), the non-point source aspect of farm-related pollution provides a barrier to adopting emissions-based instruments (Weersink and Livernois, 1996; Weersink et al., 1998; Segerson, 1990). In an effort to harness the power of private incentives, attention has been drawn to a particular form of economic instrument: voluntary cost-sharing programs (Houston and Sun, 1999; Weersink, McKitrick, and Nailor, 2001).

Since the adoption of the Clean Water Act in 1972 by the United States Government, a large number of programs administered by the United States Environmental Protection Agency (EPA) have been put into place to encourage water users to reduce their polluting activities. While not necessarily targeting agricultural practices, some of these programs did affect farming operations. In addition, the United States Department of Agriculture (USDA) created a number of water quality programs that directly targeted agricultural pollution.[5] At the outset these programs relied primarily upon giving farmers educational material about a number of best management practices (BMPs). These were, in fact, design or technology-based pollution standards, which aimed to direct the farmer’s choice of technology but initially, relied upon voluntary adoption by farmers. Since this implied higher private operating and/or capital costs and reduced profitability, farmers saw little or no immediate individual gain and had little or no incentive to adopt these new practices.[6] While there might be a future gain, the farmer might be

[5] These included: the Rural Clean Water Program (RCWP), the Water Quality Improvement Program (WQIP), the Environmental Quality Incentives Program (EQIP), and the Conservation Reserve Program (CRP). In addition, under the Small Watershed Program, the USDA provided funds to State agencies to protect watersheds and better manage water resources.

[6] Prokopy et al., (2008) review the available empirical literature on the determinants of best management practice adoption in agriculture in the United States and confirm the important role of farmer capacity (measured variously by education, income, size, capital, and access to information) and the presence of social networks as generally

risk-averse and uncertain about an eventual private payoff (Kurkalova, Kling, and Zhao, 2006)[7]. Under these circumstances, we would expect a very low rate of adoption of BMPs without the presence of some form of government incentive to compensate for the loss in immediate profits (Cooper and Signorello, 2008).

The Rural Clean Water Program of 1980 initiated the use of incentives. Funds were distributed as a share of the cost of implementing the new practices to farmers with participation on a strictly voluntary basis. With the 1985 Farm Bill (Cain and Lovejoy, 2004), however, farmers were required to employ practices in accordance with conservation plans approved by Soil Conservation Service. If they chose not to comply, then they forfeited agricultural benefits from the government. In order to ease the burden of compliance – which fell particularly upon small farming operations – the government introduced a number of different programs to reimburse farmers for a portion of the cost of installing approved best management practices (USDA, 1993). For example, under the Environmental Quality Incentives Program (EQIP) - the successor to the Water Quality Incentive Program (WQIP) -, farmers entered into five- to 10-year contracts with the government, many of which had cost-sharing components. Up to 75 percent of the costs of installing approved practices were covered by the government and, in

leading to higher adoption rates. However, the authors caution that BMPs such as water and livestock management have been underrepresented in the literature, since most work has concentrated upon conservation tillage, and, thus, less is known about the factors driving their adoption.

[7] Davey and Furtan (2008) use data from the Canadian Prairies and find that the adoption of conservation tillage technology is positively influenced by proximity to research farms that disseminate educational information, as well as farms with higher sales. Their model specification includes a measure for "environmental stress" (an indicator for a potential loss in soil quality on the farm due to adverse weather conditions in a previous time period) that can be mitigated through the adoption of conservation tillage. They find that weather variables (higher summer temperatures and lower precipitation) lead to a greater likelihood of adopting conservation tillage. This is an example of a longer-term payoff.

some cases, on-going incentive payments were provided. Along with these federal programs, most States provided adoption incentives to augment the federally provided money.

A number of studies have looked at the US experience with cost-sharing programs for improving agricultural practices relating to water quality. In addition, several surveys have been conducted in order to examine the desirability of different aspects of these programs. After reviewing the empirical evidence, a number of observations can be made.

Firstly, cost-sharing programs have likely encouraged farmers to adopt practices that they would not have otherwise done because the programs lower the cost to the farmer of implementing the new techniques. However, participation rates have been lower than expected, likely due to insufficient incentives or risk-premia (Kurkalova et al., 2006; Cooper and Signorello, 2008). Lichtenberg and Lessley's (1992) survey suggests that fewer than four percent of respondents would adopt best management practices without cost sharing, although Cooper and Keim (1996) predict higher participation rates. They combine results from a number of surveys to examine the provisions of WQIP. Their results suggest that participation rates of between 12 to 20 percent could be achieved even in the absence of cost-sharing. However, the adoption rate would not increase beyond 30 percent with the actual WQIP payments of $10/acre. Indeed, substantial payment increases would be required to encourage 50-percent adoption for any of the practices. Secondly, the higher the share of costs subsidized, the more likely farmers are to adopt desirable practices (Lichtenberg, 2004). Kraft, Lant and Gillman (1996) find that the average cost-sharing requested was 54.1 %. Thirdly, practices that are simple to adopt and compatible with existing machinery and operations are more likely to be implemented (Klapproth and Johnson, 2001).

Fourthly, farm financial factors and other farmer characteristics may matter. Lichtenberg, Strand, Jr. and Lessley (1991) find, for example, that cost sharing is used more heavily by farmers with larger operations, full time farmers, those who are older and more educated. Norris and Batie (1987), on the other hand, found that farm financial factors, as opposed to cost-sharing factors, were the most important influences on the use of conservation practices. Finally, programs that targeted specific regions thought more susceptible to water quality problems were more cost-effective than national programs (Ribaudo, Horan and Smith, 1999).

The Grand River Conservation Authority and the Rural Water Quality Program

The Grand River watershed drains an area of 6,500 square kilometres into Lake Erie in a densely populated area of Southern Ontario. The land in the watershed is largely privately owned and used for many different purposes; however, agricultural and rural land use is dominant in the northern (upstream) and southern portions. Agricultural activities are predominantly livestock-based with some field crop production (Statistics Canada. Census of Agriculture. 2006). Urban land uses are largely concentrated in the central region with the major cities being Kitchener-Waterloo, Guelph, Cambridge, and Brantford.

The Region of Waterloo developed the Rural Water Quality Program (RWQP) in 1997 with initial funding of $1.5 million over a 5 year period. Additional funds were provided by the National Soil and Water Conservation Program and the Grand River Conservation Authority. The program came into effect in 1998 with the Grand River Conservation Authority (GRCA) designated as the agency charged with delivering it. After widespread consultation with farmers, provincial agencies, other interest groups, the GRCA identified which actions would be supported, in which areas, the rate of support (grant rate) and the maximum size of grant for an individual applicant.[8] Other regions within the Grand River watershed have initiated similar programs. Wellington County, along with the city of Guelph, initiated a RWQP in Wellington County in December 1999. Funding was provided annually from these two entities and was supplemented over 2001-2003 with funding from the Ministry of Agriculture and Food's Healthy Futures for Ontario Agriculture program. In 2003 the original program was reviewed and received an additional $1.5 million in funding from the Region of Waterloo for five more years. In 2002 the cities of Brant and Brantford each invested $50,000 annually for similar programs and also obtained additional funding from Healthy Futures program. Finally, the Clean Water Project was implemented in Oxford County in 2002 when local municipalities began to offer cost-sharing grants to qualified landowners with additional funding from Healthy Futures.[9] In addition, some farms in Halton Region may be eligible to receive program funding.

In all cases, the GRCA is the umbrella agency that oversees operations of the program and they all operate in a similar fashion to the Waterloo program that is described in some detail below. Differences arise by region both in terms of the grant rates and maximum grants permitted for particular projects.

The RWQP operates by providing financial assistance to eligible farmers to share the cost of certain identified best management practices that are deemed capable of improving water quality.

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[8] Five surface water areas (the watersheds of upper Nith River above New Hamburg, Conestogo River below the Conestogo Reservoir, Canagagigue Creek, Cox Creek, and Hopewell Creek) and one groundwater priority area (between New Hamburg and Kitchener-Waterloo) were initially deemed eligible for the program.

[9] Beginning in 2009, Oxford County has expanded its Clean Water Program. It is now possible to obtain funding when improvements are made relating to woodlands and wetlands (http://www.cleanwaterprogram.ca/Oxford-program_ONHS.htm, Accessed May 13, 2009). Grant rates are between 50 and 70 % with grant maximums of either $2000 or $3000.

Best Management Practices (BMPs) are grouped into three types. Group one projects are eligible for grants only and include: livestock waste management activities such as milkhouse wastewater treatment, manure storage, clean water diversion, and livestock access restrictions; farmstead activities such as wellhead protection, the plugging of unused wells, and fertilizer, chemical or fuel storage/handling; and erosion control structures such as grassed waterways, water and sediment control basins, terraces, streambank stabilization and drop inlets. Grant rates range from 50 % (for all of the livestock waste management practices other than livestock access restrictions) to 80% for the plugging of unused wells. In addition to the grant rate, however, authorities have set a cap on the maximum amount of cost-sharing grant that a farmer can receive from the program. These caps range from \$500 for wellhead protection to \$15,000 for manure storage. Group two projects are eligible for both a grant and a performance incentive. Farmers choosing to create a nutrient management plan are eligible to a 50 % grant rate (up to a maximum of \$500) and a \$200 per year performance incentive. Strip cropping enjoys the same grant rate but with a maximum grant of \$1000 and a performance incentive dependent upon the acreage put into strip cropping (\$20 per acre per year). Stream buffers, fragile land retirement, and field windbreak projects are subject to a higher grant rate of 75 %, maximum grant of \$6,000 and performance incentive of \$250 per acre per year. An upper limit on the maximum acreage for the purposes of obtaining performance grants has also been established. Group three projects are eligible to receive performance incentives only. Thus, farmers who adopt projects such as residue management and cover crops do not receive any up-front cost-sharing grant. Rather, incentives are set at \$20 per acre per year.

In order to be considered for the program farmers must submit an application. Part of the application requires the development of an environmental farm plan (EFP). The goals of the EFP are two-fold. Firstly, farmers need to be able to identify both the environmental strengths and weaknesses of their operations. Secondly, using this information, farmers should be able to create an action plan outlining how they can best adopt more sustainable farming practices. For the purposes of the RWQP, the EFP is subject to peer review and approval. With approval received, a project can be started. Authorities from the GRCA inspect the project after completion and authorize payment of the grants/incentives but do not monitor the water quality changes that may arise from individual projects.

Empirical Analysis

Program and project type differences across regions make it possible to conduct an econometric analysis that can provide answers to the question of which design features encourage farmer participation. Two data sets are combined: the first is seven years of RWQP information (1998-2004) on the number of approved and funded projects of a particular type by year for each of the municipalities participating in the program. Table 1 provides a breakdown of the number of projects by region by year while Table 2 shows the relative frequency of project type. The additional variables available in this data set are all at the county level by year: total grants received and total invoiced costs by project type.[10] The nature of the RWQP data dictates the level of disaggregation available for doing the analysis; the most disaggregated level of data available is at the level of the census consolidated subdivision (CCS), defined by Statistics Canada for the purposes of conducting both its Population Census and its Census of

[10] Invoiced costs are total out-of-pocket expenditures by farmers on projects. Grants are based on invoices and do not include in-kind costs for which there are no invoices (e.g., own labour or materials already on farms).

Agriculture.[11] The CCS is defined at the lower-tier municipal or county level (including entities such as cities, towns, villages, townships). Thus, the unit of observation is a particular type of project in a census consolidated subdivision (CCS) for a particular year.

The RWQP data are supplemented with CCS-level data from the Census of Agriculture on farm business operating expenditures. These data provide information such as the number and type of farms; value of farm machinery and equipment; farm capital; and farm operating expenses and receipts. Since the Census of Agriculture is conducted every five years but RWQP data are available over the period 1998-2004, data from the 1996, 2001, and 2006 census years are used to interpolate and extrapolate trends in the construction of variables. In each case the average annual percentage change in the relevant variable is calculated for each individual CCS using the census period end points. For 1998-2000 this average annual percentage change is applied to the base year of 1996, while for 2002-2004 the average annual percentage change is applied to the base year of 2001.

The dependent variable is defined as the percentage participation rate (PR). It is calculated by taking the total number of projects of a specific type subsidized by the RWQP in a given CCS in each year and dividing by the total number of farms in that CCS in the same year. The resulting fraction is multiplied by 100. This variable is intended to measure the extent of farmer participation in a particular region for each of the specific types of RWQP projects.[12] While data on the total number of projects in each CCS is available for each of the years from 1998-2004,

[11] While it would have been preferable to have had data from individual farms, they are unavailable for reasons of confidentiality. The CCS is the lowest level of geography (most disaggregated) available in standard tabulations.

[12] Since the individual farm data are not available, it is assumed that a given farm undertakes only a single project of each type. However, it is not possible to distinguish whether a particular farm has undertaken more than a single project.

data on the total number of farms in each CCS is available from the 1996, 2001, and 2006 Censuses. Estimates of the number of farms for 1998, 1999, and 2000 are obtained by applying the annual percentage change in number of farms specific to a CCS over the five year period between the first two Censuses. For example, the number of farms in 1998 is estimated by multiplying the 1996 census data by two times the annual percentage change in number of farms over the period 1996-2001 and adding the result to the 1996 value. Estimates of the number of farms for each of the years from 2002 to 2004 use the annual percentage change between 2001 and 2006 but apply it to the 2001 estimate of the number of farms. The seven years of data provide 327 individual observations.

By construction, an increase in the percentage participation rate indicates that a greater proportion of farms in a region undertook a subsidized project and received cost-sharing funding. It is the interest of this paper to examine the determinants of this participation rate. Economic theory, the literature review and the available data provide the choice of variables to include in this analysis. The program design features that are included are: the maximum percentage of a project's expenses that can be covered by a grant, the maximum grant rate allowed, the maximum performance incentive allowed and a dummy variable to indicate that a project is only eligible for a cost-sharing subsidy. Squared values for each of the first three variables are also included to allow for a possible non-linear relationship. In addition to these design features, the model includes variables to account for time, average farm size per CCS, and a relative project costliness variable. Each variable is defined below, along with an explanation of its hypothesized effect on the participation rate.

The maximum grant (MG) allowed for each type of project in each county and year was obtained from the GRCA. It measures the maximum amount of money that can be obtained by undertaking a specific project. The values vary by region and project type. Since all dollar values in the previous calculations were expressed in real 1997 $ prior to undertaking the subsidy and costliness ratio calculations, the grant rates in each year have also been re-expressed in real terms. It is expected that a larger maximum grant rate is likely to increase participation, holding constant all other factors (Cooper and Keim, 1996; Kraft, Lant and Gillman, 1996; Lichtenberg, 2004). In addition to this variable, another design feature that may affect participation is the maximum percentage (as opposed to dollars) of a project that is covered by a grant. A variable (CAP) is included to model this separate effect. It is expected that the larger percentage of a project covered, the greater the participation (Cooper and Keim; 1996; Weersink, McKitrick, and Nailor, 2001). Some projects also feature performance incentives (PI) based upon the amount of acreage involved. Higher performance incentive rates may be expected to increase participation rates since they provide payments related to increases in the scale of adoption of the best management practices (Cooper and Keim, 1996). A dummy variable indicating which projects receive subsidies only (SODUM) as opposed to those receiving incentives along with the subsidies is also included to account for differential impacts of these two types of incentives. It is expected that subsidy only projects might be less likely to encourage participation since performance incentives provide on-going payments to farmers, as opposed to one-time payments.

A variable called the costliness ratio (CR) measures the average burden to the farm associated with undertaking a project. For each year/CCS/project observation the total invoiced costs are divided by the total number of projects to obtain an estimate of the average project cost per farm. This result is itself divided by the average expenditures per farm in a given CCS in a specific year from the Census data. Average expenditures per farm are found by adding together the business operating expenses from the Census and dividing the result by the total number of farms in the CCS. When the typical cost of a project increases relative to the farm's other business operating expenses, the costliness ratio increases. The expectation is that, the more costly a project is relative to the farm's operating costs, holding all other factors constant, the lower the participation rate will be, so a negative sign is expected for this explanatory variable (Lichtenberg, Strand, Jr. and Lessley, 1991).

In order to control for effects of farm size, a variable was constructed by dividing the number of farmed acres in a CCS by the number of farms in the region (LAND). This represents the average farm size in each CCS. Lichtenberg, Strand, Jr. and Lessley (1991) and Sunding and Zilberman (2000) suggest that cost sharing programs tend to be taken up by larger farms. However, Prokopy et al (2008) find evidence of smaller farms being more likely to adopt best management practices. This may be due to some form of risk sharing with the regulatory agency (Kurkalova, Kling, and Zhao, 2006; Cooper and Signorello, 2008).

Two models were estimated using the data described above. The first pooled all of the data and estimated an OLS model (equation 1) that included the variables described above, along with a time trend variable (YEAR). Other than accounting for time, this model treated observations from the same CCS as independent. These results are presented in Table 4.

$$
\begin{aligned}
&PR_i = \alpha + \beta_1 MG_i + \beta_2 MG_i^2 + \beta_3 CAP_i + \beta_4 CAP_i^2 + \beta_5 PI_i + \beta_6 PI_i^2 \\
&+ \beta_7 SODUM_i + \beta_8 CR_i + \beta_9 LAND_i + \beta_{10} YEAR_i + \varepsilon_i \qquad \text{Equation (1)} \\
&E(\varepsilon_i \mid \mathbf{X}) = 0; Var(\varepsilon_i \mid \mathbf{X}) = \sigma^2; Cov(\varepsilon_i, \varepsilon_j \mid \mathbf{X}) = 0 \ \forall i \neq j \\
&\text{where X is the vector of explanatory variables}
\end{aligned}
$$

The second and third models included the same variables as above but treated the data as an unbalanced panel to account for unobservable influences that might affect explanatory variables for a given CCS (and, hence, all of the projects and participation rates in that CCS) differently from other CCSs. If these effects are important, then OLS can yield both biased and inconsistent estimates of the coefficients of interest. Both a fixed effects model (which assumes that unobservable effects are embodied in CCS-specific constants) and a random effects model (which adds the CCS-specific unobservable effects to the random disturbance term) can be used with panel data. The former applies when the researcher believes that the unobserved effects are correlated with the included explanatory variables, while the latter assumes that such is not the case. Results from both the fixed effects (second model) and random effects (third model) are presented in Table 4. The Hausman test (p-value=0.217) cannot reject the null hypothesis that individual effects are uncorrelated with included explanatory variables. This means that the random effects model is preferred as its estimates are efficient.

It is clear from Table 4 that there is a great deal of support for the hypothesis that economic incentives play a role in influencing farmer participation in the cost-sharing program. Positive and significant coefficients are found for both the MG and PI explanatory variables in all three models.[13] However, the responsiveness to such incentives is subject to diminishing returns (negative coefficients on MG squared and PI squared, with the latter being significant).

[13] For example, a joint F-test on the six economic incentive coefficients in the OLS regression has a p-value of 0.000.

Interestingly, these design features are both defined in terms of dollars available to the farmer from the program. The CAP variable, on the other hand, describes the maximum percentage of a project covered under the program and neither its coefficient nor that of its squared term is significantly different from zero. These findings suggest that farmers respond to actual dollar incentives (rather than percentage incentives) since they can more easily be translated into the benefits to the farm relative to costs that must be undertaken to do the project. The SODUM variable suggests that the double impact of a subsidy with an on-going performance incentive may encourage even greater participation relative to a one-time subsidy. The other explanatory variables suggest that there has been an increase in farmer participation over time but that the costliness ratio is not a significant explanatory factor.[14] Using the preferred specification (random effects) the variable representing the average farm size suggests that smaller farms are more likely to participate than larger farms.

It is useful to compare these results with the analysis of cost-sharing programs such as the RWQP that was undertaken by Weersink, McKitrick and Nailor (2001). The authors began their paper by arguing that farmers would generally require a 100 % cost-share arrangement unless they either obtained benefits from behaving as good environmental stewards or else they obtained private net benefits from the adoption of subsidized practices. Following their conceptual framework, they predicted that profit-maximizing farmers would be more likely to participate in RWQ projects which offered greater private net benefits (e.g., such as manure storage) than other types of projects such as the adoption of buffer strips. However, the authors recognized that the latter would more likely result in greater off-farm benefits such as improved

[14] Given that the data are aggregate in nature, this result is not surprising. Should micro-level farm data become available, then one would expect a much stronger and negative sign on the coefficient relating to costliness of projects and farmer participation.

water quality. In this instance, Weersink et al (2001) suggested that cost-sharing programs designed to improve environmental (water) quality would need to target those practices that could best achieve the goals of the program; these would not necessarily be those that provided the highest private net benefits. Thus, in order to achieve real improvements in water quality, differential and higher subsidy and performance incentive rates would be needed to induce farmer participation in undertaking such projects.[15] The estimation results from all three models (OLS, fixed effects and random effects) in the current paper certainly support the theoretical predictions made by Weersink et al (2001): farmers are indeed responsive to higher incentive and subsidy rates.

A comparison of the first two years of project composition data presented in Weersink et al., (2001) to the seven years available for this paper (and shown in Table 2) reveals some interesting differences. During the first two years of the program, Weersink et al., (2001) report that the majority of approved projects were for manure storage and nutrient management plans. As the longer term data in Table 2 shows, however, the largest share of projects over the longer period is fragile land with fencing and nutrient management plans coming next followed by manure storage. Not surprising given our results on responsiveness to economic incentives, the fragile land and fencing choices are encouraged under the RWQP through both a subsidy with a high coverage rate, maximum dollar grant amount, and a performance incentive that is one of the more generous. Fencing projects involving livestock access restrictions are potentially able to obtain a 100 % cost share subsidy rate. This is what the estimation results presented above would suggest; that farmers are indeed sensitive to economic factors that provide more attractive

[15] Achieving a given level of abatement at least cost would also likely involve the targeting of specific farms with differential levels of financial compensation (incentives). Such “unequal” treatment, however, is not likely to be acceptable.

incentives to undertaking certain best management practices. Moreover, encouraging farmers to remove fragile land from production may have long-term benefits in terms of water quality and may be exactly what is needed in to achieve the goal of source water protection in the watershed. It would appear that officials of the programs understand this message. Beginning in 2009, Oxford County has expanded its Clean Water Program. It is now possible to obtain funding when improvements are made relating to woodlands and wetlands.[16] Grant rates are between 50 and 70 % with grant maximums of either $2000 or $3000.

We can use the results from the estimation above to predict how participation rates might change with changes in the design features of the RWQP. In turn, these participation rates can be used to predict changes in the number of projects per CCS per time period that might be undertaken. We can use these to make some simple predictions about farmer participation differences by program design feature. For example, a $10,000 increase in maximum grant allowed per project – this represents about twice the current average allowable grant - is expected to increase the participation rate per CCS by a net of 0.37% (all else held constant but accounting for diminishing responsiveness). While this appears to be a small number, this could mean an additional 2 farm projects each in regions Wellesley and Wellington with something around 500 farms. Alternatively, a performance incentive that increased to $500 – this is about four times the current average - is also predicted to increase the participation rate by CCS by 0.37% (all else held constant but accounting for diminishing responsiveness) or 2 more farm projects each per year in regions like Wellesley and Wellington.

[16] http://www.cleanwaterprogram.ca/Oxford-program_ONHS.htm, (Accessed May 13, 2009).

Conclusions and Suggestions

The Rural Water Quality Program has now been in place for ten years encouraging the adoption of a variety of best management practices aimed at improving water quality in the Grand River. Almost 2200 projects have been approved and supported through a cost-sharing mechanism and total spending has been on the order of $14 million, with slightly more than half coming from the farmers (Farwell, Boyd, and Ryan, 2008). The program has raised the general level of farmer awareness of off-farm externalities through the requirement that farmers develop an environmental farm plan, through information and support provided to farmers by GRCA staff[17], and through the selective targeting of areas and projects that are likely to lead to the most benefits (e.g., expansion of the Clean Water Program in Oxford County to woodlands and wetlands). Given the results of this paper, however, even higher participation rates could be achieved through selective targeting of performance incentives and maximum grant rates.

The piece of the puzzle that is still missing is better linkage to changes in water quality resulting from project adoption. This requires on-going and sustained measurement and monitoring of water quality measures at many places along the Grand River, a task that has not traditionally been undertaken by the GRCA. This is also a task that requires funding. While basic data collection may seem mundane, it is crucial to have baseline measures against which progress can be measured. Otherwise, scarce provincial and municipal resources may be used in an inefficient manner. This is an area that deserves further attention if programs such as the Rural Water Quality Program are to achieve positive and lasting net benefits for the citizens of Ontario.

[17] Davey and Furtan (2008) find that information dissemination to be one of the most positive influences on technology adoption.

Table – 1. Number of projects by region: 1998-2004

County	1998	1999	2000	2001	2002	2003	2004	Total	Percent
Brant					15	68	26	**109**	8.29
Dufferin					4	2	10	**16**	1.22
Haldimand					1	4	5	**10**	0.76
Hamilton					6	2	8	**16**	1.22
Halton			3	0			1	**4**	0.30
Grey							1	**1**	0.08
Oxford					8	7	8	**23**	1.75
Perth	3	14	10	1	21	36	2	**87**	6.62
Waterloo	19	32	39	71	100	141	78	**480**	36.50
Wellington	3	4	63	88	161	168	82	**569**	43.27
Total	**25**	**50**	**115**	**160**	**316**	**428**	**221**	**1315**	**100.00**

Table – 2. Frequency of project type: 1998-2004

Project Type	Frequency	Percent
Clean Water	133	10.11
Dead Stock	5	0.38
Erosion	51	3.88
Fencing	176	13.38
Fragile	281	21.37
Fuel	32	2.43
Manure	164	12.47
Manure Equipment Modification	2	0.15
Milk House Waste Water	80	6.08
NMP	179	13.61
Residue Management	38	2.89
Septic System	16	1.22
Strip Cropping	1	0.08
Water Supply	12	0.91
Wellhead Abandonment	70	5.32
Wellhead Protection	60	4.56
Cover Crops	15	1.14
Total	**1315**	**100.00**

Table – 3. Descriptive statistics

Variable[a]	Mean	St. Deviation	Minimum	Maximum
PR (Participation ratio - %)	0.58	0.67	0.04	4.28
MG (Maximum grant rate - real 1997$)	4343.58	4367.15	0	15060.24
MG Squared	3.79E+07	6.07E+07	0	2.27E+08
CAP (Maximum percentage of costs covered - %)	54.45	18.75	0	100
CAP Squared	3315.37	1816.92	0	10000
PI (Performance incentive - real 1997$)	119.57	491.32	0	2510.15
PI Squared	254954.10	1222993	0	6250000
SODUM (Dummy variable for type of incentive)	0.76	0.42	0	1
CR (Costliness ratio - %)	5.36	8.88	0	64.70
LAND (Average Farm Size in acres)	234.52	193.21	39	720
Number of Observations = 327				

Footnote: [a.] The unit of observation is project type per CCS per year.

Table – 4. Estimation results

Explanatory Variable	OLS	Fixed Effects	Random Effects
	Coefficient Estimates (std. error)[a]	**Coefficient Estimates (std. error)**	**Coefficient Estimates (std. error)**
MG (Maximum possible grant in $)	5.6E-05***	7.6E-05**	6.1E-05***
	(3.5E-05)	(3.6E-05)	(3.4E-05)
MG Squared	-1.3E-09	-3.5E-09	-2.4E-09
	(2.3E-09)	(2.1E-09)	(2.2E-09)
CAP (maximum percentage of costs covered)	-8.8E-04	-1.7E-03	-7.6E-04
	(4.0E-03)	(0.004)	(0.004)
CAP Squared	4.5E-05	4.4E-05	3.7E-05
	(4.2E-05)	(3.6E-05)	(4.0E-05)
PI (Performance incentive)	0.002*	0.001**	0.001**
	(5.7E-04)	(6.0E-04)	(6.0E-04)
PI Squared	-7.5E-07*	-4.9E-07**	-5.2E-07**
	(2.2E-07)	(2.1E-07)	(2.4E-07)
SODUM (Dummy if Subsidy only project)	-0.180	-0.302***	-0.259***
	(0.159)	(0.169)	(0.160)
CR (Costliness ratio)	0.001	0.006	0.004
	(0.004)	(0.004)	(0.004)
LAND (Average Farm Size)	-9.7E-04*	8.2E-04**	-5.7E-04**
	(1.4E-04)	(3.7E-04)	(2.6E-04)
YEAR	0.014	0.60*	0.030**
	(0.14)	(0.021)	(0.016)
CONSTANT	0.532*	0.039	0.471**
	(0.175)	(0.295)	(0.217)
Goodness of Fit	Adjusted R^2 0.2150	Within R^2 0.1258	Within R^2 0.1109

Footnotes:
[a.] Robust standard errors.
* significant at 1 %; ** significant at 5%; *** significant at 10 %

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