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AGRI-ENVIRONMENTAL REGULATIONS, POLICIES AND PROGRAMS

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Growing Forward

Abstract

The literature on the interface between agriculture and the environment is highly diverse. This paper organizes this literature into three categories: regulation; adoption of environmental best management practices by farmers; and conservation programs. Within each category, the main research questions are set forth. After reviewing select papers, suggestions for future research are discussed. Academic research in this area has been impressive, but many issues and research questions remain unanswered.

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INTRODUCTION

The literature on agri-environmental regulations, policies and programs, most of which appears in applied agricultural economics journals, is highly diverse. The purpose of this paper is to review select papers from this literature in order to highlight key findings, identify connections across the different strands of the literature and make suggestions for future research. My interest in this topic is attributable to a variety of factors. First, I am currently involved in an Agriculture and Agri-Food Canada (AAFC) project that is attempting to statistically analyze farm level adoption of environmental best management practices (BMPs). Second, I am currently writing a commissioned paper for the *Linking the Environment with Agriculture Research Network* (LEARN), that is hosted by the University of Alberta and funded by AAFC. The goal of my LEARN paper is to examine the impact of various AAFC farm income support programs on farm-level adoption of environmental BMPs. Third, I am the point person for research related to environmental regulation and innovation within the Canadian Agricultural Innovation and Regulation Network (CAIRN). Finally, my theoretical work with Murray Fulton on carbon offset markets and my theoretical work on conservation easements fits within the general research area of agri-environmental regulations, policies and programs.

Before describing the synthesizing framework that will underlie my literature review, it is useful to discuss the boundaries of my analysis. I am particularly interested in farm-level production practices that have environmental impacts. Examples that come to mind include tillage methods, fertilizer placement, pesticide use, manure management, and use of buffer strips to protect waterways. Perhaps not surprisingly, water quality will be a dominant theme. I am also interested in the intensity of farm production on a given land base, where more intensity typically implies a

greater marginal environmental impact. Intensity commonly refers to livestock stocking densities and level of application of fertilizer and pesticides, but it can also refer to the farmer's choice of crop mix (e.g., wheat versus alfalfa). Finally, I am interested in farm decisions regarding the amount of land to devote to cropping and whether or not to participate in various types of cropland and wetland conservation programs.

A large area of research that is not included in my review is society's valuation of environmental externalities and environmental enhancement programs. Valuation is central to the literature on agri-environmental policy, but it is not central to farm-level decision making. A second area of research that is not included in my review is carbon offset opportunities for agriculture and other related aspects of greenhouse gas (GHG) emissions. Thirdly, I do not discuss research related to biofuels and renewable energy opportunities for agriculture. Finally, I have purposely excluded issues related to international trade, multilateral negotiations, multifunctionality and the broader field of ecological goods and services associated with agricultural production.

My review of the literature on agri-environmental regulations, policies and programs does not describe the specific policies that AAFC and other governments use to promote agri-environmental outcomes. AAFC has a suite of sustainable development strategies (SDS) that are designed to integrate environmental, economic and social outcomes. SDS are central to AAFC policy priorities, which are summarized in their "Growing Forward" policy platform: (1) A competitive and innovative sector (e.g., innovations to reduce environmental impacts); (2) A sector that contributes to society's priorities (e.g., safe food and water, sustainable food production); and (3) a sector that is proactive in managing risks and inducing investment.

I have chosen the following three research areas for categorizing the literature on agri-environmental regulations, policies and programs.

- Regulation of various aspects of production (e.g., manure; use of pesticides, water use, water contamination, right-to-farm)
- Promotion of environmental BMP adoption through cost sharing, farm environmental planning, education, etc.
- Cross and conservation compliance programs, including targeted land and water conservation programs

For each area I intend to identify the key research questions, briefly discuss some of the literature that has addressed these questions, and then make some suggestions for additional research. The majority of the literature is empirical, although I discovered that there are several interesting theoretical models that have been specifically designed to analyze agri-environmental outcomes. After my review of the literature on conservation programs, which mainly focuses on payments to farmers for the provision of environmental services, I remind readers that any type of decoupled farm payment, including a conservation payment, will typically result in more intense input utilization by farmers. This potential dilution of the benefits of a conservation payment has not been previously discussed in the literature.

AGRI-ENVIRONMENTAL REGULATIONS

The economics of regulation occupies only a minor niche in the agricultural economics literature, so it is not surprising that comparatively few papers have been published on regulating environmental aspects of agriculture. The literature on agri-environmental regulations has tended to focus on nutrient management, water quality, pesticides and right to farm legislation. The

majority of papers that focus on regulation are descriptive and empirical. The small number of papers that have made a creative theoretical contribution tend to be published in top-ranked field journals, including *Journal of Environmental Economics and Management*, *Land Economics, Ecological Economics* and the *American Journal of Agricultural Economics*.

Regulation can be viewed from a variety of perspectives including positive, normative and political economy. With a positive perspective, the relevant questions include: what types of regulations are currently in place; how do regulations vary across different jurisdictions; what are the unintended consequences of specific regulations; are the regulations and the associated monitoring systems cost effective; have the regulations been evolving to keep up with new technologies and changes in environmental outcomes; and are there obvious cases of regulatory capture? With a normative perspective, the relevant questions include: when should regulation be used instead of a market-based approach to externality reduction; should the regulation be broad-based or targeted; who has the property rights to the natural resource and thus who should be compensated when regulations result in a redistribution of rents, and what type of enforcement structure and set of legal sanctions should be used to achieve desired outcomes. With a political economy perspective, the relevant questions include: what type of lobbying generated the initial legislation; is lobbying responsible for legislative updating or the prevention of legislative updating; and, probably most importantly, has lobbying for agri-environmental regulations been efficient in that it achieves regulations with a positive benefit – cost outcome?

Most of the literature on agri-environmental regulations focus on water that is contaminated with farm nutrients and the impact of pesticide use by farmers on food, worker safety and the health

of natural ecosystems. Most regulations are implemented in the form of standards, which are mandated levels of performance that are legally enforceable. There is a large literature on when and why standards in general are superior to market-based instruments. A discussion of the advantages and disadvantages of standards relative to market-based instruments is beyond the scope of this review. For this paper it is sufficient to note that standards are typically used in aspects of society when human health and safety is a key consideration. In general, agri-environmental regulations and standards are not efficient instruments because they are time consuming and costly to implement and change, they largely ignore farmer heterogeneity and they are typically strongly influenced by interest groups who will be positively or negatively impacted by the change. Due to these limitations important externalities are often under or over regulated.

Livestock and Nutrients

Smith et al. (2006) examine nutrient regulations in a livestock intensive region of southern Alberta. One of the key results from their spatial analysis is that manure composting is more cost effective than trucking the manure away from the region in order to comply with maximum phosphate standards. Weersink and Eveland (2006) test the pollution haven versus agglomeration hypothesis with respect to whether regional differences in manure policy affect where new hog barns are built. The authors do not find support for the pollution haven hypothesis and thus do not believe that policy harmonization across regions will have a significant impact on the distribution of nutrient flows.

Metcalfe (2001) finds that manure regulation compliance costs are significant for small U.S. hog operations but not for large operations. Hence, more stringent regulations are unlikely to result in a large-scale relocation of hog barns away from hog-intensive regions. Feinerman et al. (2004) incorporate nutrient demand relationships into a spatial equilibrium model in order to estimate the welfare effects of manure nutrient standards. Surprisingly, standards that achieve large scale reductions in nutrient applications only result in 5 - 15 percent welfare loss for livestock operations.

Van Der Vlist et al. (2007) use a stochastic production function approach to examine the technical efficiency of Dutch horticultural operations. They demonstrate that stricter agri-environmental regulations increases the technical efficiency of Dutch farmers. Latacz-Lohmann and Hodge (2003) describe European agri-environmental policy as one that has evolved from command and control regulation to payments to farmers for the provision of public goods. They suggest that key challenges for policy effectiveness include a lack of spatial targeting and a poor distinction between income support and agri-environmental objectives.

Pesticides

Freshwater and Short (2005) indicate that a lack of harmonized pesticide standards for the U.S. and Canada has resulted in inefficient price differences. They estimate that the net gain in aggregate social welfare from removing price discrimination across the two jurisdictions is likely to be small. However, increased harmonization will likely be strongly opposed by interest groups because of rent redistribution. Goodhue & Wiersma (2001) are concerned that pesticide regulation in California is generating more social costs than benefits. Even if the regulations are

such that marginal benefit is equal to marginal cost, a regulation may have a net negative social value if the setup, monitoring and implementation costs are large.

Carter et al. (2004) examine how California growers make pesticide substitution choices when faced with a pesticide ban. Data on production costs and crop yields with alternative fumigants, specific regulations concerning fumigant applications and the shapes and sizes of California fields are used to infer the farm level cost of pesticide regulations and to measure the interaction affects of different regulatory requirements. Zilberman and Millock (1997) argue that most pesticide regulations do not reflect economic principles. They are optimistic that economic principles will become prominent in new pesticide regulations because natural scientists are developing a better awareness of the contribution of economics, and economists are becoming more careful when incorporating biological considerations into their economic models.

Right-to-Farm

McCormally (2007) indicates that most Canadian provinces have some type of right-to-farm legislation. The general intent of the regulation is to reduce the incidence of nuisance lawsuits by urban dwellers who live near farms. Typical complaints by urban neighbors include odour, noise, smoke, dust, vibration and light. Individual property rights are usually such that in the absence of right-to-farm legislation, courts are likely to impose injunctions and award damages to people whose lives have been impacted by the activities of a neighboring landowner, even if the neighboring landowner was conducting business as usual. Farm practices review boards commonly mediate urban-rural right-to-farm disputes before they reach the court system.

Adelaja and Friedman (1999) indicate that most U.S. states also have some type of right-to-farm ordinances. This form of regulation became popular in the 1980s when policy makers noticed that farm viability was being increasingly threatened by municipal regulations that prevented farmers from engaging in normal farming practices and by lawsuits that are launched by urban neighbors. The authors use a logit regression model to show that legislation is stronger in regions where farmers have more political clout. However, legislative strength does not appear to be associated with the presence of other agri-environmental policies.

Suggestions for Future Research

Pennings (1996) suggested that farmers should be required to have a permit when utilizing or disposing of nutrients such as phosphorus from manure, and that these permits should be allowed to trade on a commodity futures market. The attractiveness of centralized trading for futures contracts is that it promotes efficient price discovery and facilitates hedging for the purpose of price risk transfer. Pennings' suggestion is interesting because poor information flows and inefficient price discovery often prevents the emergence of cash markets for tradable permits. Pennings proposal is most likely to work in a livestock intensive region with well established manure nutrient regulations.

Another suggestion for future research is to examine the unintended consequences of regulations that are designed to manage farm nutrients and pesticides. Gurtoo (2007) thoroughly discusses the unintended impacts of agri-environmental regulation. An example of an unintended impact of regulation that is discussed by Gurtoo is the switch by food manufacturers to more energy intensive packaging to comply with material recycling laws. It should be noted that an

unintended regulatory impact is not necessarily bad because farmers will normally innovate to lower the cost of complying with a regulation. Consequently, the innovation that was unintended from the perspective of the policy maker can result in unintended welfare gains. In general, theoretical and empirical modeling of the unintended consequences of agri-environmental regulation is an area of research that deserves more attention.

A third suggestion for future research is to examine the social costs and benefits of simultaneously strengthening right-to-farm legislation and imposing higher environmental standards on farmers. In the absence of standards, farmers who degrade the environment are vulnerable to a lawsuit, even with existing right-to-farm legislation because the courts may attribute the damage to an "abnormal" farming practice. A simultaneous strengthening of right-to-farm legislation and environmental standards is well suited to the manure/biogas market. It is currently difficult for farmers to receive permission to build centralized anaerobic digesters because regional citizens are typically concerned with digester safety, potential odour and heavy truck traffic. Municipalities that are contemplating strengthening manure disposal regulations should also be considering amending right-to-farm legislation to ensure that the construction of a centralized digester is feasible.

Finally, there has been little research concerning how farm level decisions are negatively impacted when farmers operate with compliance uncertainty. Feller and Sink (1984) indicate that the U.S. meatpacking industry faces thousands of regulations. Managers of meat packing firms consistently identify that not knowing if they are operating in compliance and not knowing the extent of legal sanctions is an important source of managerial inefficiency. For farmers, an

aversion to uncertainty about regulatory compliance will result in inefficient management decisions such as operating with too few cattle or applying an inefficiently low level of fertilize during seeding. A survey that asks farmers about their concern over regulatory compliance is likely to generate a set of interesting and useful results.

ADOPTION OF AGRI-ENVIRONMENTAL BMP'S

The literature on farm-level adoption of environmental best management practices (BMP) is large and remains an active area of research. Over the past two decades studies have emerged from many different regions throughout North America, Europe, Asia and other countries in the developed and developing world. The various papers in this literature are surprisingly similar in format and methodological approach. The main objective of this mostly empirical literature is to identify common features of farmers who tend to adopt environmental BMPs such as conservation tillage, environmentally friendly crops, riperian buffer strips and nutrient management plans. Papers in this literature tend to assert rather than formally derive theoretical relationships between environmental BMP adoption and exogenous explanatory variables, which are described below.

Variables that measure farmer and farm attributes are normally obtained from farm survey data. The explanatory data are generally classified as farm type variables (e.g., cattle, hogs, intensive grain), land attribute variables (e.g., hilly, near waterways, status of soil nutrients), farm financial variables (e.g., debt, net worth, gross farm income, off-farm income), farmer characteristic variables (e.g., gender, age, education, experience) and farmer awareness variables (e.g., participation in environmental farm planning and enrolment in agri-environmental cost sharing

programs). The dependent variable in the regression equation normally consists of some measure of BMP adoption (e.g., percent of acres devoted to conservation tillage). The next step in the formal BMP analysis involves choosing an appropriate empirical model (e.g., single equation logit versus systems of equations OLS). Once the model is in place theoretical hypotheses are then developed for the sign and significance of the coefficients on the right hand side variables in the regression model. The final step is to run the regressions and analyze the results. Statements can then be made such as "Older farmers with more education and high net worth are most likely to adopt an environmental BMP".

The four most common types of environmental BMPs that have been examined in the literature are conservation tillage, environmentally friendly crop choice, use of field boundary buffer strips and nutrient management plans. Conservation tillage includes zero tillage and reduced tillage. Zero tillage has a high investment cost but also has a high level of environmental benefit. Reduced tillage varies widely in terms of both cost and benefit. With both types of tillage the environmental benefit appears as reduced levels of soil erosion either by wind or water (erosion by water typically results in waterways that become contaminated with soil nutrients). Unlike many other environmental BMPs, farmers often obtain sizeable private benefits from investing in conservation tillage techniques (e.g., conserve soil moisture, fuel cost savings, less compaction).

A good example of an environmental friendly crop mix is a crop rotation that includes alfalfa. This crop is desirable because alfalfa has comparatively high nutrient uptake and beneficial soil maintenance features. Buffer strips are strips of permanent vegetation, usually near waterways, that can effectively reduce the movement of sediment, nutrients, and pesticides across farm

fields. Nutrient management plans are site specific planning guides that are used to ensure that farm nutrients in the form of manure and chemical fertilizers are incorporated into the land in a way that minimizes the environmental impact. The plan describes maximum nutrient application rates, procedures for nutrient placement and timing of nutrient placement.

Lamba et al. (2009) provide a nice overview of the BMP literature and the various theoretical hypothesis about environmental BMP adoption. They find that site-specific conditions such as annual precipitation, cropping system and topography are important determinants of environmental BMP adoption. Equally important are farm characteristics including land ownership, type of agricultural enterprise, farm size and annual sales. A farmer's involvement in environmental organizations is a strong indicator of BMP adoption, and perceptions of trust and reciprocity between the farmer and the agency involved with BMP promotion is also important. Finally, information obtained from peers tends to carry more weight in farm-level decision making than information obtained from other sources such as the media and the science community.

Canadian studies on adoption of conservation tillage and sustainable crop mixes include Traore et al. (1998), who focus on potato production in Quebec, Davey et al. (2008), who focus on the Canadian prairies and Ghazalian et al. (2009), who focus on sustainable crop mixes in Quebec. Lamba et al. (2009) use correlation analysis to comment on associations between attributes of Canadian farmers and BMP adoption. In a departure from the standard methodology, Ghazalian (2010) uses a translog cost function to estimate the farm-level cost of BMP adoption for Canadian farmers. Sparling and Brethour (2007) combine the results from a farm-level survey

and a farm economic model to calculate the overall net cost to a farmer who adopts conservation tillage. In both Ghazalian (2010) and Sparling and Brethour (2007) cross region comparisons are a key part of the analysis. Beaulieu (2005) summarizes the findings of a large Statistics Canada survey of BMP adoption by Canadian farmers. Of particular interest is the detailed matrix of environment BMP with column categories corresponding to "air", "water", "soil" and "habitat" and the row categories corresponding to "right rate", "right time" and "right place".

In the U.S., Featherstone and Goodwin (1993) examine the adoption of conservation tillage practices by Kansas grain farmers and conclude that differences in farm income, size and farming technique explain differences in adoption decisions. As well, corporations tend to make larger investments and older farmers tend to make smaller investments in conservation tillage. Kim et al. (2005) examine the factors affecting BMP adoption decisions of Louisiana cattle producers. They find that BMP adoption is more likely with a larger number of enterprises, more contact with extension personal, a higher level of education, a higher percentage of income from cattle production and the greater the hilliness of the farmer's land. In Australia, D'Emden et al (2008) determined that farmers are more likely to adopt conservation tillage when a reduction in tillage achieves a comparatively large decrease in the use of pesticides and allows for an earlier planting of row crops in low rainfall regions. Farmers who hired an outside consultant and who regularly attended cropping extension activities were also most likely to adopt conservation tillage practices.

Policies that Affect BMP Adoption

Increasing farmer participating in environmental farm planning is a common agri-environmental policy objective in many agricultural regions. An environmental farm plan (EFP) is a voluntary assessment prepared by a farm manager that serves to increase the manager's environmental awareness of their production practices. Environmental strengths and weaknesses are identified and realistic actions plans are developed as part of the planning process. Cost share programs for implementing environmental projects are often available to farmers who participate in the planning process. Robinson (2006) discusses the Environmental Farm Plan (EFP) scheme, which was established in Ontario in 1993. The EFP scheme focuses on soil management, water quality and storage/disposal of agricultural wastes. Dupont (2010) combines Statistics Canada Census of Agriculture data with seven years of data from Ontario's Rural Water Quality Program for the Grand River in a Heckman two-stage model to examine how financial incentives affect environmental BMP adoption rates by farmers. Ribaudo et al. (2004) indicate that in the U.S. the Environmental Protection Agency (EPA) requires all intensive livestock operations to file nutrient management plans. Ribaudo et al. are interested in measuring the farm level cost of developing and adhering to a particular plan.

Another important agri-environmental policy is BMP cost sharing. Weersink et al (2001) argue that cost sharing programs are potentially highly effective, but Ontario's blanket approach to distributing funds has severely reduced actual effectiveness. Yank and Weersink (2004) use an integrated economic, hydrologic and GIS model to examine the targeting effectiveness of policies that assist farmers with the creation of riparian buffers in agricultural watersheds. DeVuyst and Viju (1999) propose a group incentive contract for BMP cost sharing in order to reduce moral hazard problems and achieve efficient risk sharing. Engel et al. (2008) discuss

payments for environmental services (PES) at a more general level. They note that PES are well suited for situations where farmers are marginally profitable or where farmers have a powerful lobby because the approach used is "beneficiary pays" rather than "polluter pays". Obubuafo et al. (2008) examine how producer awareness of the Environmental Quality Incentives Program (EQIP) translates into active participation in this program by Louisiana beef producers.

According to Pannell (2003) an important determinant of farm level adoption of various types of BMP is uncertainty. He argues that farmers will approach the adoption decision with skepticism, uncertainty, prejudices and preconceptions. Moreover, policies that promote environmental BMPs must explicitly recognize that farmer adoption attitudes are an important constraint when designing a particular program. Mitchell and Hennessy (2003) agree that uncertainty is a major determinant of whether or not an environmental BMP is adopted. They argue that "green insurance", which pays an indemnity in the event of a BMP failure, would be an effective way to improve BMP uptake by farmers. Similarly, Govindasamy and Cochran (1997) identify the need for incorporating an explicit compensation for risk of adoption failure when designing voluntary conservation programs that promote farm level utilization of BMPs.

A final area of research associated with BMP agri-environmental policies is the construction and use of BMP indicators. According to McKay et al. (2010), BMP indicators are derived using science-based models that integrate land use data (e.g., number of livestock and crop choice) with biophysical data (e.g., climate, precipitation, soil type and topography). The indicators are used to inform policy decisions and evaluate the success of agri-environmental programming

through trend analysis. Kalff and Lefebvre (2010) describe the work of Agriculture and Agri-Food Canada in the development of 14 BMP indicators that are organized within six categories: environmental farm management, soil quality, water quality, agri-ecosystem greenhouse gas emissions, agri-ecosystem biodiversity, and production intensity.

Suggestions for Future Research

Despite a large and diverse literature on the adoption of environmental BMP by farmers, the number of consistent results and general principles that emerge from this literature is disappointedly low. Knowler and Bradshaw (2007) review a large number of environmental BMP studies and discover very little consistency in quantitative outcomes. Similar findings were obtained by Prokopy et al. (2008), who also show that variable significance is highly dependent on the particular statistical approach. For example, Knowler and Bradshaw find that the farmer's age variable has a significant positive effect on adoption in 3 out of 18 studies, a significant negative effect on adoption in 5 out of 18 studies and an insignificant effect in the remaining 10 studies. The analogous values are 6, 2 and 10 for farm size and 3, 3 and 3 for the land slope variable.

My view is that better theoretical frameworks are required to guide the empirical research. Rather than including all available survey variables as right-hand side explanatory variables in the regression, only the variables that have solid theoretical underpinnings should be included. The empirical analysis can then largely be devoted to testing specific hypothesis about the sign and size of the estimated coefficients, including interaction effects. The conceptual models that are used to guide the empirical analysis should certainly go beyond the standard economic

framework. For example, the behavioral economics literature, which emphasizes concepts such as status quo "lock in" and cognitive dissonance, should be included in the analysis ob BMP adoption decisions. Stonehouse (1996) provides a good starting point for a multidisciplinary analysis of environmental BMP adoption.

Theoretical analysis will likely reveal many new variables that should be included in the empirical models of BMP adoption. The impact of risk on farm input and land use decision making has been examined in many studies including Babcock (1992), Horowitz and Lichtenberg (1993), Smith and Goodwin (1996), Wu and Adams (2001), Mishra et al. (2005) and Rajsic et al. (2009). This literature should be better incorporated into models of environmental BMP adoption by farmers. On a related issue, the theory of real options suggests that farm income uncertainty and sunk cost are both critical determinants of adoption. Similarly, some measure of industry wide network effects would likely have strong explanatory power in a model of BMP adoption. Finally, measures of economies of scale and scope, and variables that measure information diffusion are likely to add valuable explanatory power to empirical models of environmental BMP adoption.

I do not have a strong empirical skill set, so prior to my review of the BMP adoption literature I spent considerable time reading through graduate level textbooks on econometric procedures for cross sectional and panel data. What I discovered is that high quality research on discrete choice decision making pays considerable attention to the econometric deficiencies. Indeed, the starting point for high quality empirical analysis is that problems such as omitted variables, errors in measurement and endogeneity of right-hand side variables are all present by assumption, so the

goal of the applied econometrician is to take the necessary steps to minimize the estimation biases that are caused by these problems. Unfortunately, in the environmental BMP adoption literature these critical features of empirical modeling are often ignored. This lack of attention to critical issues such as omitted variables possibly explains a good deal of the inconsistency in results that was discovered by Knowler and Bradshaw (2007) and Prokopy et al. (2008).

CROSS AND CONSERVATION COMPLIANCE AND TARGETED PROGRAMS

The purpose of this section is to discuss the broad and diverse literature on non-regulatory government programs that are designed to improve agri-environmental outcomes. The first section examines two types of compliance programs that utilize the "stick" approach to improving agri-environmental outcomes. Following that, voluntary targeted conservation programs are discussed. The distinction between a voluntary targeted conservation program and cost sharing program for environmental BMP adoption is blurry because in both cases the "carrot" approach is used to enhance the agri-environmental outcome.

Cross and Conservation Compliance

The term cross compliance is commonly used to refer to a class of European policies that require farmers to comply with various forms of environmental BMPs in order to be eligible for decoupled payments. Similarly, the term conservation compliance is commonly used to refer to a class of U.S. policies that restrict farm production practices on highly erodible land (e.g., buffer strips, cover crops) as a condition for program payment eligibility.

Brady et al. (2009) describe how decoupled Single Payment Scheme support payments are

provided to EU farmers whose land qualifies as Good Environmental and Agricultural Condition (GEAC) and who adhere to various other cross compliance restrictions. These authors are concerned that environmental stewardship will decline if agricultural activity declines due to the elimination of traditional price support programs. Mosnier et al. (2009) examine two specific cross compliance measures in France: compulsory buffer strips along rivers and crop diversity. Based on their results from a static bio-economic programming model that endogenizes cross compliance (e.g., penalties for violations), Mosnier et al. conclude that decoupling in the absence of cross compliance achieves few environmental benefits. Hence the cross compliance feature of EU policy is very important.

In the U.S. Hoag and Holloway (1991) describe the federal conservation compliance program, which was designed in the mid 1980s to require owners of highly erodible farmland to file a specific conservation action plan in order to enroll in various government support programs. Govindasamy and Cochran (1995) indicate that conservation compliance programs are a complement to soil-conserving BMPs and should be analyzed as such. Govindasamy and Cochran (1997) use a stochastic dominance approach to estimate the size of the risk premium that is needed to compensate farmers who enroll in risk-enhancing conservation programs. Gardner et al. (2010) discovered that even though recent U.S. commodity programs have been explicitly decoupled, the effect of program payments on land use has been very significant. Their simulation results show that 22 percent fewer acres would have been cultivated if program payments had been reduced to half of their observed level.

Targeted Conservation Programs

Claassen et al. (2008) ask whether competitive bidding for targeted benefits and participant screening through use of cost-benefit analysis has improved the effectiveness of U.S. environmental programs. They conclude that repetitive auctions with few new participants have reduced the effectiveness of competitive bidding. Moreover, although targeting based on cost benefit analysis has proven to be effective, the practice is controversial because of the unequal distribution of benefits across farmers. According to Langpap (2006), land use restrictions that are imposed because of the presence of endangered species on farmland may have unintended consequences. Specifically, landowners may eliminate the endangered species so as to avoid the land use restrictions. Langpap argues that financial incentives for farmers to preserve endangered species are needed to reduce the impact of these negative incentives.

Several papers focus specifically on wetland preservation. Van Kooten (1993) uses an optimal control model to estimate the shadow value of marginal farmland in agricultural production. He finds that agricultural subsidies raise the marginal value well above payments for wetland preservation and as such farmers have little incentive to preserve wetlands. Laporte et al. (2010) find that in the province of Ontario wetland preservation is hampered by multiple political jurisdictions (province, municipalities and regional conservation authorities), each of whom govern watersheds. Crepin (2005) makes a useful theoretical contribution by comparing take-it-or-leave-it conservation contracts with uniform contracts. With the former both the land area and the payment is specified, and with the latter only the payment per unit of land area is specified and farmers choose how many acres to commit. The critical determinant of which type of contract is superior is shown to depend on the extent of asymmetric information.

Another area of the agri-environmental literature focuses on targeting effectiveness. Babcock et al. (1997) examine efficiency losses when programs are based on costs or benefits alone rather than a benefit cost ratio. The correlation of costs and benefits is an important determinant of the size of the efficiency loss. Tanaka and Wu (2004) are interested in targeted policies for reducing fertilize usage by U.S. farmers who produce fertilizer intensive crops. They conclude that higher government payments for conservation reserve land would disproportionately increase the retirement of land that is not fertilizer intensive. Similarly, a targeted payment for farmers who abandon a continuous corn rotation for a corn – soybean rotation would not achieve significant reductions in fertilizer use. Tanaka and Wu conclude that the most effective instrument for reducing fertilizer use is a targeted fertilizer tax. Falconer and Hodge (2001) argue that targeted pesticide taxes are required to achieve pesticide reduction goals in U.K. agriculture, but alternative tax specifications vary considerably with respect to the magnitude and direction of their impact (including negative side effects). Finally, Lankoski (2003) use Finnish data to show that a differentiated fertilizer tax and a differentiated buffer strip subsidy are generally required to simultaneously achieve biodiversity enhancement targets and fertilizer reduction targets.

Program Design with Asymmetric Information

It is well known that asymmetric information is a major constraint when attempting to design an efficient conservation payment scheme. In the extreme case a single conservation payment to all farmers can result in a highly varying distribution of environmental benefits (Fraser, 2010). Agricultural economists have used insights from the mechanisms design literature to achieve more efficient targeting. In one of the earliest studies on this issue, Wu and Babcock (1995) show how menus of contracts can be designed to ensure that farmers do not misrepresent

themselves with respect to the potential environmental benefits that can be generated from their farming operations. Bontems et al. (2005) argue that asymmetric information is likely to have a spatial dimension as well as the standard cost of provision dimension. They show how a system of non-linear taxes and subsidies can be designed to achieve cost efficient environmental goals when multiple information constraints must be considered. Feng (2007) developed a model where governments can simultaneously achieve environmental goals and income support goals by making program payments a non-linear function of farm size. Overall, the income support goal reduces the conservation distortion that is caused by the asymmetric information. Giannakas and Kapland (2005) examine non-compliance by U.S. farmers who receive program benefits in an ex post moral hazard framework.

Latacz-Lohmann and Van der Hamsvoort (1998) demonstrate that competitive bidding by farmers in an environmental auction is an efficient way to allocate conservation payments. Although auctions can increase the cost effectiveness of achieving environmental targets, strategic bidding in auctions with multiple rounds is problematic from an efficiency perspective. Rolfe et al. (2009) argue that it is unrealistic to expect farmers to reveal their private cost in a single-round sealed bid conservation auction. Indeed, until a reasonable amount of learning has been achieved, farmers will tend to underbid. Open bidding auctions with multiple rounds can significantly improve the efficiency of conservation outcomes due to an enhanced learning environment.

Suggestions for Future Research

The literature on conservation programs is far from complete. With respect to economic theory,

there are many outstanding issues involving asymmetric information, optimal procedures for conservation auctions, optimal length of a conservation contract, contract enforcement, and valuation of unintended consequences. Additional empirical studies on the cost-benefit ratio of conservation payments and the associated spillover effects are needed to guide real-world implementation of theoretically sound programs. Detailed farm surveys that are designed to assess how farmers view their participation in conservation programs are also needed to better ensure that programs have design features which are attractive to farmers.

An important issue that has been overlooked in the literature is the unintended impact of conservation payments on increased input use by farmers. Hennessy (1998) demonstrated that seemingly decoupled farm program payments can result in higher applications of fertilizer and pesticides because the payment makes farmers less risk averse and thus less wanting to reduce input use as a way to cope with the risk. This so-called insurance effect of countercyclical payments was also examined by Antón and Le Mouël (2007) and Goodwin and Mishra (2005) in the specific context of decoupled farm income support in on-going U.S. Farm Bills. In Vercammen (2007), I show that risk aversion is a sufficient but not necessary condition for a linkage to exist between a decoupled payment and farm output. In my model standard financial insolvency rules that govern bankruptcy are sufficient to create an investment – direct payment linkage.

Payments to farmers for the provision of environmental services or green payments that are designed to compensate farmers who adopt environmental BMP are similar to a decoupled farm payment. It therefore logically follows that these payments, which are specifically designed to

achieve a desired environmental benefit, will generally have the undesired effect of inducing farmers to use farm inputs such as fertilizer and pesticides more aggressively. The extent that unintended increases in the farm level application of fertilizer and pesticides offsets the intended environmental benefit of the payment is important from a policy perspective. Theoretical and empirical analysis of this issue appears warranted.

CONCLUSIONS

The first objective of this paper was to organize a subset of the literature on the interface between agriculture and the environment into three general areas: regulation; farm level adoption of environmental best management practices (BMPs); and conservation programs. Over the past two decades analyzing environmental BMP adoption by farmers has been responsible for much of this literature. While many important insights have been generated, it is fair to conclude that agricultural economists still do not have a good understanding of why and when farmers make BMP adoption decisions. Although individual studies generally yield a full set of statistically significant results that appear to align with economic theory, when viewed as an aggregate there is little consistency across the various studies. I interpret this to mean that the theoretical underpinnings of the empirical models are overly ad hoc. Hopefully future studies on BMP adoption will be based on a more robust theoretical framework.

There are many good papers on various aspects of agri-environmental regulation, but overall this area of research is wide open for analysis. Are the issues associated with agri-environmental regulation distinct from the economics of regulation in general? I believe the answer is yes, and thus unique theoretical models should be developed to analyze these issues rather than relying on

the models of regulation from the general economics literature. One area that may become important in the future is markets for tradable farm nutrient disposal permits. The relationship between the stringency of environmental regulation and the shadow price of marginal land that is capable of accepting nutrients is an area that is ripe for large scale empirical analysis.

Many countries are gradually replacing a command-and-control and cross compliance approach to achieving desired agri-environmental outcomes with a targeted conservation payment approach. The targeted approach places high emphasis on farmer heterogeneity, and is based on the premise that financial incentives are probably the most efficient way to steer farmers toward making decisions that are social welfare maximizing rather than private profit maximizing. Policy makers face many challenges when designing targeted conservation programs. Agricultural economists have made a good start toward helping policy markers work around these challenges, but a great deal more work in this important area remains.

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