Ex post liability versus *ex ante* bonding as instruments for addressing environmental impacts of genetically modified crops.

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Introduction

There has been enormous growth in the use of biotechnology in food crop production. In 1999 approximately100 million acres were planted to genetically modified (GM) crops, four times more than the area in 1997 (James 1998). Despite this growing use, concerns have been raised in both the popular press (e.g., Bonham 1999) and scientific articles (Butler *et al*. 1999) regarding the potential for the widespread release of GM crops to result in environmental damage. In part, this view is fostered by concerns that GM crops are being released without adequate knowledge of their long term environmental impacts (Mander and Goldsmith 1996; Butler *et al.* 1999) or, in some countries, without procedures to deal with environmental problems that may occur (Hruska and Lara Pavón 1997). Currently the decision to release a GM crop within United States is based on an assessment of the risks of environmental, health and other potential damages (Mooney and Klein In Press). Although considerable research is being undertaken to understand these risks, opinions differ regarding the probability of environmental damage.

Potential environmental damages from GM crops could be localized, affecting individual landowners or, widely dispersed, affecting the welfare of society as a whole. Markets for environmental services are often incomplete or non-existent and as such the environmental effects of biotechnology may not be effectively internalized in private decisions. A central issue in the design of environmental policy is the choice of the appropriate instrument for internalizing externalities (Baumol and Oates 1988; Shavell, 1984; Weitzman 1974). The efficient choice will be a function of the nature of the potential external effects, and firm characteristics. In the US, once a GM crop has passed the permitting, testing and tolerance requirements there are no

statutory remedies for public or private parties that are damaged by users or manufacturers of an approved GM crop (Lewis 1997). Instead, the US along with most other countries will rely on the default mechanism of addressing grievances through tort[1] actions based on liability rules (Lewis 1997).

Ringleb and Wiggins (1990) and Shavell (1986) indicate that tort liability may not deter risky behavior when (1) there is a long latency period between the use of a technology and the realization of the harm; and (2) total damages exceed the assets available to the defendant. Recent experience with oil spills from the Exxon Valdez or cases of endangered species' habitat restoration have illustrated that environmental damages can be costly (or impossible) to mitigate and may occur at a point in time later than the initial deleterious actions.[2] Ecosystem damage as a result of releasing GM crops could be widespread, appear following a time delay and be similarly costly.

In this paper we investigate the potential for using bonding mechanisms as an *ex ante* tool to address the potential environmental impacts of GM crops instead of (or as a complement to) *ex post* liability. Environmental bonds can encourage safety research within companies (Perrings 1989), guarantee a minimum level of compensatory or cleanup funds in cases where damage occurs, and assist in allaying consumer fears surrounding the environmental impacts of GM

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[1] Tort law concerns compensable wrongs that do not arise from breach of contract and cannot be remedied by an injunction against future interference. The economic purpose of tort liability is to induce injurers to internalize externalities my making then compensate the victim (Cooter and Ulen 19XX)..

[2]For example, the Columbia river has been dammed, diverted and salmon spawning habitat destroyed. These cummulative factors have led to the decline of salmon populations over time.

crops. Two avenues of enquiry are investigated. Firstly, does the environmental release of biotech crops lend itself to regulation through a structure such as a bond? Secondly, are bonds a more efficient instrument than tort liability in the case of environmental release of GM crops? Or should bonds be thought of as a complement to liability rules?

We find that in the case of GM crops, a bonding mechanism is likely to be effective under the same conditions as tort liability. The main advantages to bonding over a liability rule are protection against bankruptcy risk, incentives to conduct up-front safety research and the potential for products to be brought to the market sooner. The main disadvantages are that bonds can be costly to administer and impose liquidity constraints for the firm.

Background

Environmental benefits and potential damages from GM crops

Much of the concern surrounding the environmental release of biotech crops focuses on their potential to provide environmental (ERS 1999), production and other benefits verses the potential for environmental damage (several studies are summarized in Clark 1997, 1998, 1999 and Krimsky and Wrubel 1996). A common genetic modification to agricultural crops is the addition of genes from *Bacillus thuringiensis* (*Bt*.) to create resistance to certain insect pests or gene modification to obtain tolerance to specific herbicides.[3] Crops with "built in" resistance to insect pests can reduce the application of insecticides (ERS 1999) and potentially decrease environmental externalities such as chemical residues and deaths of non-target organisms.

[3]Modifications that provide other benefits are discussed in Marks, Freeze and Kalaitzondonakes (In Press).

Herbicide tolerant crops enable producers to use herbicides more effectively, killing weeds with fewer chemical applications (ERS 1999). It is anticipated that genetic engineering can be used to make crops resistant to major diseases and environmental stresses that traditionally have caused large losses, thereby not only stabilizing yields but also reducing the use of fungicides and other agents that inhibit the onset of diseases.

Environmental damages could result from the development of herbicide resistence in weeds[4] as a consequence of using a single herbicide on herbicide resistant GM crops and insect resistance to *Bt*. as a result of frequent exposure to *Bt.* crops (Tabashnik 1994). *Bt*. is a naturally occurring insecticide commonly used by organic farmers. Insect resistance to *Bt*. could significantly damage profits from organic farming and the success of integrated pest management schemes. In addition, it is possible that GM crops could outcross with weedy relatives, transfering attributes such as herbicide and insect resistance to these species making them difficult to control. Out-crossing could result in a number of undesirable consequences including altered community structure, food chain composition and genetic and biologic diversity in addition to the persistence of weeds on agricultural lands or adjacent wild habitat (Rissler and Mellon 1996; Adam and Köhler 1996; Saat 1996).

Previous investigations of environmental bonding

The idea of environmental bonds is related to early literature on materials use fees (Solow 1971; Mill 1972) and deposit-refund systems (Bohm and Russell 1985). In situations where there is potential for environmental damage, an individual firm, manufacturer or third party posts a

[4]Heap (1999a) reports 216 herbicide resistant weeds worldwide in 1998, of which 74 resistant weeds are present in the US and 24 in Canada (Heap 1999b).

bond with a regulatory authority. When the firm demonstrates that there is no longer any potential environmental harm the regulator releases the bond. In the case of mining, for example, firms post bonds to ensure post-mining site reclamation. When the firm demonstrates that the site has been reclaimed, the bond is released.

Environmental bonds have been examined as a potential economic instrument to resolve water quality problems from agriculture (Weersink and Livernois 1996); agricultural non-point source pollution (Shogren, Herriges and Govindasamy 1993), reduce the generation of space debris (Macauley 1992) as well as a wide variety of other situations (Carman 1997; Cornwell and Costanza 1994). There has, however, been no investigation of the suitability of environmental bonds to address potential harms of GM crops.

Precautionary principle, tort liability and environmental bonds

Under the precautionary principle, firms must demonstrate that their commodity meets safety criterion (e.g., no offsite impacts) before they are allowed to market the product. In contrast, tort liability and environmental bonding recognize that products may not be totally "risk free" and instead provide deterrent effects and some means to partially or fully compensate any resulting damages.

Liability and bonds are similar mechanisms in that each provides a financial incentive for firms to mitigate potential external effects. Under tort liability, a damaged party can bring a suit under common law to recover compensatory damages. The prospect of large damage settlements provides an incentive for firms to ensure product safety.

However, the deterrent effect of tort liability is insufficient if the firm lacks enough assets to cover damages. In effect, the firm's assets are the upper bound on liability. In this case the firm

is said to be "*judgement-proof*," and *ex post* damage awards will not provide adequate deterrence against the risky activity (Shavell 1986).

One solution to the judgement-proof problem is to require, up-front, collateral such as a bond. The collateral bond is not necessarily an actual transfer of funds to be held by a regulator, but rather is an obligation to pay in the event of some damage. This provides the agent with a direct monetary incentive to improve product safety and/or comply with environmental regulations. In both cases (i.e. tort liability and bonding) the deterrent effect is strongest when the costs of identifying and assigning blame for damages are low. Damages, such as pervasive weediness, can be initially identified for low cost by visual inspection. Unlike tort liability, the bond provides potential damaged parties with partial protection against default risk as if the agent fails to perform, the bond is forfeited and used to remedy the performance failure.

Perrings (1998) suggests several advantages for choosing to regulate using environmental bonds. First, the bond would provide an upfront measure of value regarding the potential environmental damages; second, it would provide incentives for firms to conduct additional safety research before releasing their product; third, it would insure society against the conjectured loses. Although the collateral bond reduces the firm's moral hazard, it introduces a moral hazard problem on the side of the regulator. A wealth-maximizing regulator, for instance, may have the incentive to retain the bond whether or not reclamation is performed. If, however, the operating permit specifies reclamation requirements that can be verified by a third-party at a low cost, the firm should be able to successfully challenge the regulator's decision. Moreover, a state that establishes a reputation for such behavior would have future difficulty attracting capital

to its jurisdiction, and a surety provider would be unlikely to underwrite contracts held to be held by that state.

Environmental Bonds for GM Crops

Conditions for successful environmental bonding

Shogren, Herriges and Govindasamy (1993) use examples from the coal mining industry to identify conditions when bonds are likely to be effective. These are: (1) well-known damage valuations; (2) a high probability of detecting environmental damage; (3) few parties; (4) a fixed time horizon; (5) a well-defined agreement (e.g., both parties have the same definition of *environmental damage*); (6) a low bond value (relative to company assets); and (7) no irreversible effects. These conditions are discussed below in relation to the case of environmental bonds for the release of GM crops.

Bond the manufacturer or individual producer?

One question to examine is which party should be required to post the bond: manufacturers of GM crops (lifescience companies) or the individual producers growing GM seed. Requiring individual producers to post environmental bonds will present liquidity constraints, which are likely to be binding for firms with limited assets. In some instances, a third party surety may agree to cover the amount of the bond reducing liquidity constraints. However the producer would still be required to pay an annual premium (typically one to five percent of the face value of the bond), and the bond is a liability that will adversely effect the producers'

credit.[5] Given this constraint, life science companies are better candidates to post the bond as they have "deeper pockets".

In addition, requiring a bond from manufacturers rather than individual producers is advantageous as this reduces the number of agents posting a bond.[6] Commercialization of biotech products has led to considerable industry consolidation (Marks, Freeze and Kalaitzondenakis 2000) resulting in a lifescience industry that is dominated by relatively few large players worldwide. This supports the enforcement of environmental bond agreements for the release of GM crops and reduces monitoring, enforcement and transactions costs.

Other Industry characteristics

An application of environmental bonds to life science companies that wish to release GM crops into the environment meets several of the criteria suggested by Shogren, Herriges and Govindasamy (1993). These are identified below and followed by a discussion of industry characteristics that could be problematic for an environmental bonding scheme.

Many of the adverse effects from the release of GM crops are likely to be observable. For example, pervasive weediness or build up of insecticide resistance within pests could be identified initially through visual inspection and confirmed with further testing. Life science companies have employed slightly different methods to impart traits such as herbicide tolerance

[5]For a discussion of liquidity constraints in coal mining see United States General Accounting Office (1988).

[6] In general, this creates a serious monitoring problem in the principal-agent relationship, making suppliers responsible for the potentially negligent actions of their customers; in the case of GM crops, however, the manufacturer has presumably made assurances that the product will not be ecologically disruptive in virtually any form.

and pest resistence into agricultural crops. Through genetic testing it would be possible for a regulatory agency (or a landowner) to pinpoint which life science company product was the cause of the harm. As such there is a high probability of detecting environmental damage and pairing this with a specific GM crop manufacturer.

A bond with a fixed time horizon could be developed for regulating GM crops and would have several benefits. Firstly, the firm knows for what period of time their capital will be tied up; secondly, it facilitates choosing a discount factor and lastly the time horizon makes it more likely that a third party will post a bond. A fixed time horizon will also provide a finite period of time during which to gather additional information on the environmental impacts of the crops. When new GM crops are first released, both regulators, manufacturers and producers have the least information regarding their environmental consequences. The bond could be posted for a period of time sufficient to allow additional testing and data collection over several seasons. If their release is more or less risky than first anticipated the bond value could be adjusted accordingly[7] (the decision could be made by an agreed to third-party contractor as a means to mitigate potential moral hazard on the side of the regulator). Data analysis and collection during this period could indicate whether additional bonds should be required in subsequent periods.

The requirement that both parties should have a clear agreement could be determined by inventorying possible future states of nature and listing these as conditions of the bond. Some potential environmental problems associated with GM crops e.g. outcrossing with wild and weedy relatives, could be irreversible if left unchecked. However monitoring and testing during

[7]Perrings (1989) discusses sequentially determined bond values.

the period of the bond could identify these problems early increasing the probability of successful clean up.

The most problematic conditions to fulfil for successful environmental bonding of GM crops are the requirement of well known damages and low bond value relative to company assets. To value the costs associated with environmental damage the potential sources of damage must be identified. Scientific debate tends to point to similar possible adverse events. It would be possible to value each of these states of nature (although it is possible that no account has been made for some other unexpected event) however estimating a probability associated with their occurrence could be problematic.

In the case of a bond posted for mine clean up activities, the geographic extent of these activities tends to be known and related to a single site. The environmental release of biotech crops differs from this in several ways. First the same products will be released at many different sites all with slightly different environmental conditions and thus the geographic extent of damage could be very wide or localized depending on local conditions. Further there is the question of international environmental damage. Biotech crops produced by a single company are grown in several countries. Damage disbursed on a wide geographical scale could make the value of the bond very large indeed.

Problems of potentially large environmental damages, and uncertainty regarding the magnitude and nature of environmental damages are impediments that must be overcome for the successful design and implementation of environmental bonds. However, on the whole it appears that environmental bonding could be used as an instrument to regulate the release of GM crops.

Environmental bonding versus tort liability

An advantage of a liability rule over bonding is that if there is no harm, there are no administrative costs of running the system.[8] All costs are incurred from the point in time that environmental damage has been identified and not before. In addition, given that environmental damage from GM crops could be easy to identify this provides a strong incentive for companies to engage in safety research. An environmental mishap would be likely to increase public demands for stringent regulation of future GM product development and implementation, bolstering the incentive for biotech firms to remediate any damages. In addition, the broad and often negative publicity in the popular press regarding biotech innovations (Kalaitzondenakis and Marks 1999; Marks and Mooney 2000) provides a powerful incentive for the company to engage in clean up. In contrast, there are a variety of costs associated with the bonding rule, prior to any damages. These include costs of calculating the expected damages, costs to the firm of securing a third party to post annual premiums of bond, and the opportunity cost of capital held for the bond. Under either instrument some study of the potential economic costs is required. However under a liability rule these are not incurred until damages take place while under a bonding mechanism these will be paid for up front to determine the price of the bond.

Tort liability has limitations when there is a long latency period between an action and its effects. For example, the company may have gone out of business before damages are found. Similarly environmental bonds are also limited in these situations but for different reasons. First, there is the constraint of having capital tied up for long periods of time. Second, because of

[8]See Shavell (1984) for a discussion of the relative costs of private tort regulation versus public safety regulation.

uncertainty, surety providers are unlikely to underwrite bonds over time horizons where there is considerable uncertainty.

Perhaps the most significant advantages of environmental bonds are to redistribute the burden of proof from plaintiff under liability rule to defendant and their liability to guarantee a minimum amount of funds for clean up operations. However this raises an interesting issue as firms that would not be affected by liquidity constraints of posting a large bond are unlikely to be significant default risks (e.g., Exxon did not go bankrupt as a result of its compensatory and punitive damages after the Valdez spill). In other words, the bonding mechanism adds administrative costs above the liability rule, without any reason to believe that the outcome is different.

Finally environmental bonding could provide an advantage over tort liability in terms of the time period required to release a product on the market. If a firm is willing to provide a significant bond this can be taken a signal that the firm feels confident in the safety of its product and should be allowed to market it. Under a liability rule, the firm may have to wait a longer period of time before releasing the product.

Conclusions

In many respects liability rule and environmental bonds are complements, not substitutes. Both instruments utilize the deterrent effect of financial penalties (court ordered compensatory damages or bond forfeiture) as incentive mechanism, and both are likely to be effective under similar conditions. The major differences are (1) the bond partially insures against a default risk; and (2) the burden of proof is on the defendant rather than the plaintiff under a bonding

mechanism. Neither the bond nor tort liability is likely to be effective if there are long latency periods between cause and effect. Therefore, if this is a source of environmental change associated with GM crops, some form of command and control regulation is likely to be a superior option.

Despite limitations of bonding mechanism, firms are likely to prefer posting a bond to the constraints of the precautionary principle. With the precautionary principle, the firm must in effect go to court and prove its innocence before it can introduce its product. With a bond in place, the firm can market its product and there must be some evidence of environmental harm before firm has to incur heightened standard of proof to recover its bond.

References

Adam, K. D. and W. H. Köhler. 1996. Evolutionary Genetic Considerations on the Goals and Risks in Releasing Transgenic Crops. In Wöhrmann, K. Tomiuk, J and A. Sentker (Eds.). Transgenic Organisms - Biological and Social Implications. Birkhäuser Verlag Basel, Switzerland.

Baumol W.J., and W. Oates.1988. The Theory of Environmental Policy (2nd Edition). Cambridge University Press.

Bohm, Peter and Clifford S. Russell.1985. "Comparative analysis of alternative policy instruments," in A. Kneese and J. Sweeny (eds) Handbook of Natural Resource and Energy Economics. New York: Elsevier Science Publishers, 395-460.

Bonham, K. 1999. Biotech and the Butterfly. *AGWEEK*. June 14, 1999.

Butler, D., Reichhardt, T., Abbott, A., Dickson, D., and A. Saegusa. 1999. Long-term Effect of GM Crops Serves up Food for Thought. *Nature*, **398**:651-656.

Carman, Maureen D. 1997. "Regulatory and Transactional Bonding: A Primer on Surety Bonding for the Mineral Lawyer," *Proceedings of the Seventeenth Annual Eastern Mineral Law Institute*. 7-1(23).

Clark, E. Ann. 1997. Risks of genetic engineering in agriculture. Http://www.oac.uoguelph.ca/CRSC/faculty/eac.risks.htm

Clark, E. Ann. 1998. Environmental risks of genetic engineering in field crops. Http://www.oac.uoguelph.ca/CRSC/faculty/eac.naec.htm

Clark, E. Ann. 1999. Debunking the myths of genetic engineering in field crops. Http://www.oac.uoguelph.ca/CRSC/faculty/eac.myths.htm

Cornwell, L., and R. Costanza. 1994. An Experimental Analysis of the Effectiveness of an Environmental Assurance Bonding System on Player Behavior in a Simulated Firm. *Ecological Economics* 11:213-226.

Economic Research Service. 1999. Genetically Engineered Crops for Pest Management. June 25th, 1999. United States Department of Agriculture. Http://www.econ.ag.gov/whatsnew/issues/biotech.

Hruska, A.J. and M. Lara Pavón. 1997. Transgenic Plants in Mesoamerican Agriculture. Zamorano Academic Press, Honduras.

James, C. 1998. Global Review of Commercialized Transgenic Crops: 1998. *ISAAA Briefs* No.8. ISAAA: Ithaca, NY.

Kalaitzondonakes, N. and L.A. Marks. 1999. Public Opinion of Agbiotech in the US and UK: A Content Analysis Approach. Selected Paper. American Agricultural Economics Association Annual Meeting, August 8-11, 1999, Nashville, Tennessee.

Krimsky, S. and R. Wrubel. 1996. Agricultural biotechnology and the environment: Science, policy and social issues. University of Illinois Press, Urbana.

Lewis, S.K. 1997. "Attack of the Killer Tomatoes?" Corporate liability for the international propagation of genetically altered agricultural products. 10 *Transnational Lawyer*. 153.

Macauley, M.K. 1992. In Pursuit of a sustainable Space Environment: Economic Issues in Regulating Space Debris. Discussion Paper, Energy and Natural Resources Division, Resources for the Future, Washington, D.C.

Mander, J. and E. Goldsmith. 1996. The Case Against the Global Economy. Sierra Club Books, San Francisco.

Marks, L. A., Freeze, B. and N. Kalaitzondonakes. In Press. The AgBiotech Industry - A U.S.-Canadian Perspective. *Canadian Journal of Agricultural Economics*.

Mill, E.S. 1972. Urban Economics. Scott Forseman, Glenville, IL.

Mooney, S. and K. Klein. In Press. Environmental Concerns and Risks of Genetically Modified Crops: Economic Contributions to the Debate. *Canadian Journal of Agricultural Economics*.

Perrings, C.1989. "Environmental bonds and environmental research in innovative activities," *Ecological Economics*. 1:95-110.

Ringleb, A.H., and S.N. Wiggins. 1990. Liability and Large Scale, Long Term Hazards. *Journal of Political Economy* 98(3):574-595.

Rissler, J., and M. Mellon. 1996. The Ecological Risks of Transgenic Crops. MIT Press, Cambridge, Massachusetts.

Saat, T. A. W. M. 1996. Out in the Open: Field Trials with Genetically Modified Crop Plants in Four Europen Countries, Chile and the United States. In Schmidt, E.R. and T. Hankeln (Eds.) Transgenic Organisms and Biosafety: Horizontal Gene Transfer, Stability of DNA, and Expression of Transgenes. Springer-Verlag Berlin Heidelberg New York.

Shavell, Steven. 1984. "Liability for harm versus regulation of saftey," *Journal of Legal Studies*. 13:357-374.

Shavell, Steven (1986) "The judgment proof problem," *International Review of Law and Economics.* 6:45-58.

Shogren, J.F., J.A. Herriges and R. Govindasamy. 1993. Limits to environmental bonds. *Ecological Economics* **8**:109-133.

Solow, R. 1971. The Economist's solution to pollution control. *Science* 173:498-503.

Tabashnik, B. E. 1994. Evolution of resistance to Bacillus thuringiensis. *Annual Review of Entomology*, **39**: 47-49.

United States General Accounting Office (1988) *Surface Mining: Cost and Availability of Reclamation Bonds.* Washington, DC: Government Printing Office

Weersink, A and J. Livernois. 1996. The Use of Economic Instruments to Resolve Water Quality Problems from Agriculture. *Canadian Journal of Agricultural Economics* **44**:345-353.

Weitzman, Martin L. 1974. Prices vs. Quantities. *The Review of Economic Studies*. 41:477-91.