NEW ZEALAND INSTITUTE FOR THE STUDY OF COMPETITION AND REGULATION INC.

Genetically Modified Organisms and Liability: What are the issues?[1]

Stephen R. Hutton,
Institute for the Study of Competition and Regulation
June, 2004

Abstract:

This paper examines the main economic issues surrounding liability for genetically modified organisms, with focus on the New Zealand situation and liability debate, and in particular the interaction between liability and regulation.

1.0 Introduction

Use of genetically modified organisms (GMOs) potentially offers important benefits for New Zealand, but may also pose significant risks. The nature of GMOs are such that many of the costs of accidents will fall on third parties that have no contractual relationship with the GMO user, and so GMOs can be considered to produce negative externalities. It is a standard result in economics that market outcomes are inefficient in the presence of externalities when agents cannot costlessly negotiate, and that this can be solved by shifting external costs and benefits to the party making the decisions. This then provides that party with the appropriate incentives to make efficient decisions. A liability regime is one means of trying to internalise these externalities by shifting the external costs of using GMOs onto GM firms.

This paper examines the main economic issues to be considered when designing a private liability regime. The challenge in designing an efficient private liability regime is to create a legal framework that provides incentives for private parties to take socially desirable actions. Thus, the prime consideration in evaluating different elements of such a regime is the incentives these elements will create. An efficient liability regime will provide incentives for parties to take an efficient level of precaution, and to run only socially desirable projects.

2.0 The potential for harm

[1] This paper is drawn from material covered in detail in Hutton (2003). Many of the arguments discussed in brief here are analysed in formal economic models in this thesis, as is a broader review of the economic theory of liability.

In order to analyse liability regimes, it is necessary to first have a clear outline of the nature of possible accidents that GMOs might cause. It is important to understand that this is a statement about potential harm, not a statement that GMOs will necessarily turn out to cause these types of accidents.

The level of risk posed by GMOs is highly controversial. The Royal Commission on Genetic Modification (Eichelbaum 2001) contains comments from a range of respected scientists, and represents the most complete set of views available. The Commission's recommendation to "proceed with caution" is based on a belief that the benefits of GMOs outweigh the risks, when these are properly managed – but not a belief that the risks posed by GMOs are non-existent.

Four types of harm might be inflicted by GMOs.

2.1 Personal injury

The first type of accident risk is the potential for personal injury or damage to human health. This may occur from exposure to or consumption of GMOs, such as if genetically modified foods or pollens prove toxic or trigger allergies (which can range from mild to potentially fatal).

The Royal Commission also noted submissions about the possibility of personal injury from medicines designed using genetic modification technology. While such medicines may pose risks, they must go through the rigorous testing that all new pharmaceuticals pass through. There appears to be no evidence that pharmaceuticals designed through GM technology are more likely to be more dangerous than those developed using other techniques, so the existing requirements is likely to be sufficient. Another concern is harm from dietary supplements, where controls are less rigorous (Eichelbaum 2001, p60).

There is also the possibility that new diseases could be created through use of genetic modification. As the Commission notes:

> "The major perceived risk arising from the use of DNA from other microorganisms as transgenic vectors is the possibility of the generation of new diseases through recombination of the vector sequences with DNA from known pathogens." (Eichelbaum 2001, p46 para 13)

However, this could only occur from experiments in controlled laboratory environments, and so the risk of damage from such diseases is minimal if proper laboratory safety precautions are taken. This risk would be similar to that posed by existing experiments using pathogens, with the exception that escape of a disease created through GM may be more serious in that humans will not have encountered the particular disease and so may have no existing antibodies.

2.2 Property damage and economic loss

The second type of damage that could occur is property damage or economic loss to parties as a result of GMO release, such as through contamination of a non-GM crop by GMOs. In particular, economic loss may occur from loss of organic certification by a farmer due to GMO contamination, and so loss of the price premium they are able to charge for organic products. The circumstances under which certification loss occurs will depend on the specific requirements for organic certification that growers face. If such certification has

very little tolerance for contamination, then this form of economic loss will be much more common than if certification levels allow more tolerance.

It seems likely that organic certification requirements for New Zealand growers will be influenced by international organics standards, such as those created by the International Federation of Organic Agriculture Movements, as organic production will be primarily aimed at export markets. International standards will be determined by major organics producers overseas, and are unlikely to be affected by the New Zealand liability regime. Such international standards reject GM crops of any sort as being organic, but tolerance levels will have to be set at a level that growers in other countries are able to meet, and so may not include zero tolerance for contamination, as this may be unrealistic in countries where there has already been release of GMOs, or where release has occurred nearby.

Use of GMO crops could also reduce returns to conventional farmers (for example, by GMO farmers being able to undercut prices due to cheaper production methods), but this would serve as a desirable market-based signal to farmers that more efficient technology was available. No liability regime will (or should) compensate for such effects: they do not cause inefficiencies.

2.3 Environmental damage

A major concern for many is the potential for widespread environmental damage from the introduction of GMOs, such as loss of biodiversity. There is fear that genetically modified crops (or weeds that cross-pollinate with such crops) or animals (such as fish) may be stronger than natural varieties and so may choke out native species, either through out-competing them for space, food or habitat or by hybridisation. There are also concerns about potential impacts on non-target species.

In some cases it may be hard to demonstrate to a court that appreciable harm has occurred. It may be difficult to prove that damage occurred from a particular GMO, and to trace that damage to a particular injurer if there are multiple parties using the GMO. As the damage is likely to be widespread, there would be very little incentive for individuals to mount tort actions for environmental damage, leaving such action up to government discretion. These problems limit the effectiveness of any tort liability regime, whether under strict liability or a negligence rule.

There is also the unlikely possibility of catastrophic or irreversible damages from GMOs in some manner that is currently unforeseen. The potential for irreversible damage from GMOs is more than from some other new technologies and hazardous activities because biological organisms are able to reproduce themselves in the wild, whereas the effects of other activities such as chemicals or even radiation will fall over time.

2.4 Spiritual pollution

A final form of potential costs and damage from GMOs comprises the "ethical costs" of GMOs and what has been termed their "spiritual pollution" (such as concerns expressed to the Royal Commission by religious groups and many Maori). These are real social costs because there are clearly some groups who put some value on these issues. However, such costs are very difficult to quantify. It is difficult to envision how any liability regime could deal with such damages. It would be difficult for a particular party to establish to a court's satisfaction that a GMO had harmed that party or that the harm was of a particular quantifiable amount, let alone that a particular injurer was responsible for the harm and

should be held liable. Researchers or users may also have little information on what these costs are or how to alleviate them, and so providing incentives for precaution to reduce the risk of spiritual harm may be difficult, and such incentives may be of limited effectiveness.

As private liability is not likely to deal with spiritual concerns, the only solution may for ERMA to consider these issues in assessing whether an application gains consent. This will encourage applicants to consider spiritual issues so as to increase the probability that their application will be accepted. ERMA is currently required to consider ethical concerns (ERMA, 2000) and Maori concerns about "the relationship of Maori and their culture and traditions with their ancestral land, water, sites, waahi tapu, valued flora and fauna and other taonga." (ERMA 1998, p.10) in its application process, so it may be that no changes are required here. Nahkies et al (2003) find that many of these groups do not feel that their views are considered, particularly for non-Maori with ethical concerns about genetic modification.

It is clear that tort liability systems are better suited to handle personal injury, property damage and other economic losses rather than environmental damage, because errors in measuring damages are high in the latter case and these damages are spread over a large number of victims, and so there is little incentive for individual victims to initiate lawsuits. Such lawsuits will only occur for widespread environmental damage when class-action suits occur, or where government initiates civil suits against injurers. However, the standard theory of liability (which considers accidents that harm a single victim) is useful for examining liability policy for personal injury, property damage and economic loss.

There has been little discussion of alternative non-tort-based liability regimes to cover these other damages. There needs to be more such discussion and consideration of whether such costs will either be left to lie where they fall, be dealt with by ex-post government compensation related to individual crises or whether some formal government compensation scheme (like ACC) should be designed. Since environmental damage is by nature fairly widespread, it is likely that such damage will fall be left to lie where it falls by default.

3.0 Comparisons with other activities

If there is a successful liability regime in place for dangerous activities similar to GMOs, then we could adopt that liability regime without performing a separate analysis for GMOs. If no such clearly successful regime exists, then we need to undertake a separate analysis of liability for GMOs.

3.1 Comparable activities

There have been a number of comparisons made between GMOs and different classes of activities. The closest comparison is between organisms created through genetic modification techniques and those created through other methods, from controlled pollination and hybridisation to mutagenesis and cloning (which are specifically excluded from the definition of GMOs in legislation).

Many of the same risks apply to these other crops: if a herbicide-resistant crop is created through some other technique, then it has equal chances of cross-pollinating with weeds and causing environmental damage as one created by genetic modification.

Because these are outside the definition of genetic modification, their liability status will not be affected by any changes in the liability regime for GMOs. Thus, adopting a new regime for GMOs would create a legal inconsistency.

Attention has been drawn to other hazardous activities, particularly nuclear power, chemical/toxic waste and asbestos.

Nuclear power involves risks of very high potential damage that may have very long-lasting adverse effects (despite not being irreversible in the strict sense of the word, as radioactive materials will eventually decay). There are clear and highly effective precautions that can be invested in by injurers in the design of plants (such as containment structures and redundant safety and plant shutdown systems) and in security/safety personnel and equipment, while there are few precautions that victims can take other than from not locating themselves near a nuclear plant. The catastrophic nature of serious nuclear accidents suggests that any major accident would bankrupt the plant owner, and so they may be "judgement-proof", since the courts will not be able to make them pay the full cost of an accident. Liability insurance for such damage can also be very expensive, because of the risk of moral hazard (very technical precautions are difficult and expensive to monitor) leading to inadequate precaution, and because of the ambiguous probability of accidents. These suggest that a negligence regime may be better than strict liability for nuclear power.

Nuclear power has been governed under a range of liability regimes, but there have been many suggestions that regime design was heavily influenced by political economy rather than optimality considerations, and did not lead to efficient outcomes (Brown, 1999). While there have been relatively few accidents and no major disasters at nuclear plants in countries with western tort liability systems, this does not necessarily indicate that these regimes have been successful, as the probability of an accident occurring may have been higher than it would have been with efficient precautions.

Another activity compared to GMOs is the liability system for contamination by toxic waste or chemicals. As with GMOs, the harm inflicted may not show up for many years after an "accident" occurs, and so the injurer might not exist as a legal entity by the time damage is discovered. There is also a significant judgement-proof problem, since damages awarded to victims after major accidents often leads to injurer bankruptcy. This has led to the creation of "Superfund" in the USA, a fund designed to pay for cleanup of contaminated sites, funded through compulsory levies on industry members. This has had mixed success, and has been criticised because it provides poor incentives for individual firms to change their behaviour, and because a large proportion of the fund has been spent on administrative and legal costs, rather than pollution cleanup or compensation. Toxic waste accidents commonly affect large numbers of people who individually have little incentive or ability to sue (because of legal costs, which are often very high as lawsuits can take many years). As class action suits are rare, there is a perception that the probability of injurers being sued and found liable are low, and so a belief that there are insufficient incentives for injurer precaution. Many states in the USA have adopted strict liability regimes for toxic spills, and Alberini & Austin (1999) find that those states that have adopted strict liability tend to be those where more accidents have occurred, but that imposing strict liability does reduce accident rates.

A third activity that has been compared to GMOs is that of asbestos. Viscusi (1996) argues that liability has been a poor solution for asbestos. He suggests that liability had little impact on precautions, because the extent of harm (and of liability) was unknown when harm occurred, and so firms had little incentive for precaution when precaution decisions were made. He also suggests that compensation was poor, because mass tort cases lead to damage

claims exceeding the assets of injurers, and litigation costs were almost triple the actual compensation received by victims.

Thus, these similar activities do not give uncontroversial precedents (successful or unsuccessful) on which to base a liability regime for GMOs.

3.2 Treating like-with-like

Generally speaking, law should be consistent - activities with similar levels of risk should be equally under the law (Law Commission, 2002). If similar activities are treated differently, this may be perceived as unjust, and may distort investment decisions towards equally risky but non-GMO technology. Thus, it is argued that GMOs should not have a separate liability regime, and should be treated in the same way as existing activities.

While this is a good argument, there is a strong alternative view; if the current liability regime is not optimal for activities with certain risk characteristics (high ambiguity, potential for irreversible, widespread or catastrophic damage, etc.) because of incomplete internalisation of negative externalities, then the fact that such a regime is the status quo does not justify continuing to apply non-optimal policy to new activities. For example, there are many markets where externalities are currently not internalised (such as carbon dioxide emissions), but this does not justify a decision not to internalise externalities for future markets. Because of this, the "like with like" argument does not necessarily mean that GMOs must be treated the same way as similar risky activities under the status quo.

Ideally, we should treat activities and technologies by the properties of the final product (including its risk profile) rather than the method of creation. While this is a desirable goal, it may be infeasible to so if there are no clearly identifiable (and legally verifiable) properties by which legislation or regulation can discriminate between products, in which case the method of creation may be used as a rough proxy for properties of the product and its the level of risk. In practice there is a tradeoff between the costs of inconsistency and the costs of not having a liability regime that best suits a particular activity.

If we do not believe that GMOs are similar to other risky activities, then there is a clear justification for evaluating an alternative liability regime. So what is it that makes GMOs different?

First, there are several characteristics of the potential risks that GMOs pose that are not shared by most other risky activities, such as the potential for catastrophic and irreversible damage, the lack of information about the probability and magnitude of accidents, the irreversible nature of some damage, the difficulties in proving causation of harm and the time lags between the activity and discovery of damage.

Second, GMO crops may be inherently different from conventional crops, because they have the potential to cause economic harm through loss of organic certification from contamination. In other words, they may cause accidents that existing activities cannot.

Third, some argue that GMOs are different because of their spiritual, cultural and ethical costs. While many people do not hold these values, it is clear that there are people who feel strongly that genetic modification is inherently wrong - ie for whom GMOs would inflict disutility that they would pay to avoid - and so to that extent, these costs are real. There also seems to be a strong public perception that GMOs are different from other forms of science,

as demonstrated by many of the 10,000 public submissions to the Royal Commission and the nature and existence of the Commission itself. Whether this is a sufficient justification for designing a new liability regime is unclear, as the costs involved are hard to value.

In the absence of a clear answer as to whether or not GMOs are different from other activities, and without clear evidence that the liability regimes for other activities are optimal, we are justified in conducting a separate analysis to determine the optimal liability regime for GMOs, rather than simply adopting an existing regime on the grounds of similarity. In addition, this analysis may also be useful for considering liability issues for other hazardous activities.

4.0 Designing a liability regime

An efficient liability regime will provide the incentives for parties to take the efficient level of precaution and make efficient activity level decisions. An economic analysis of liability inherently assumes that people and firms are "rational" and so act to maximise their expected utility, which is a function of their wealth. This means that the best way to get parties to take precautions is to provide clear incentives for them to do so, particularly financial incentives. Efficient outcomes can be achieved by designing these incentives so that utility-maximising decisions by economic agents are the same as those that would be made by a theoretical fully-informed social planner. The main dispute in the economics of liability lies in what regime is likely to achieve this.

4.1 Strict liability vs negligence

The main division in opinion is over whether strict liability or some form of negligence rule will lead to more efficient outcomes.

Under a negligence rule, injurers are liable if and only if they fail to take some particular level of precaution, which could either be a specific set of precautions stipulated by a regulator or an undefined duty of reasonable care that will be determined by the courts on a case-by-case basis. Negligence rules can promote efficiency if designed correctly by setting the required level of precaution equal to the efficient level of precaution.[2] This will then provide injurers with incentives to take efficient precaution so as to avoid liability. It will also leave victims with incentives to take efficient precaution, as they bear residual liability if the injurer is non-negligent and so wish to minimise accident and precaution costs. Contributory negligence can also exist in conjunction with a negligence rule, though there is generally no gain in efficiency from doing so. Negligence can be problematic if precautions are non-observable, as injurers cannot be found negligent for not taking precautions that the court cannot observe (or verify).

Under strict liability, injurers are liable for damages (generally set equal to the level of harm caused by accidents) if an accident occurs, except in cases of particularly defined defences (such as natural disasters or deliberate sabotage by a third party). This liability applies even if the injurer took all reasonable precautions to prevent an accident from occurring. Strict liability can lead to efficient precaution decisions if precaution is unilateral, as it internalises externalities by placing the costs of accidents on the sole party who can reduce risks. Strict liability may also be efficient in cases of bilateral precaution when there exists a defence of

[2] The standard way of determining whether an injurer is negligent is known as the "Hand Rule" after Judge Learned Hand. Effectively, it results in the injurer being found negligent if their precaution level was less than the efficient level.

contributory negligence, where the injurer is strictly liable unless the victim fails to take a stipulated level of protection, as this also provides incentives for victims to take precaution in order to avoid liability. Strict liability is valuable since it provides incentives for injurers to take non-observable precautions, because injurers receive the benefits from taking such precaution in lower expected accident costs.

In both cases, it must be proved both that damage occurred, and that that the damage was caused by the activity of a particular injurer in order for that injurer to be liable.

The current liability regime for GMOs can roughly be described as providing strict liability for significant, foreseeable harm to land from dangerous activities, but a negligence rule for foreseeable harm to other property or economic loss (Todd, 2000). This may not be optimal.

4.2 Nature of precautions

In order to know what incentives are required to attain the efficient level of precaution, it is important to have an accurate characterisation of the precautions parties can take to reduce the level of harm. Different beliefs about the nature of precaution will lead to different beliefs about the optimal liability regime. Despite its fundamental importance, there has been little attention in the debate thus far paid to the nature of precautions.

There are many questions that need to be answered to form an accurate picture. First, are there any precautions that can be taken, and will these be effective in reducing risk? If precautions are ineffective in reducing the risk of accidents, then providing incentives for precautions is relatively unimportant, and pursuing equity goals (such as providing compensation) might be a more important goal of a liability regime. In contrast, if precautions are highly effective then it is very important to provide the correct incentives for parties to take precautions, and compensation will be less important.

Second, who can take these precautions? If only one party can take precaution ("unilateral precaution"), then liability should be allocated to that party, whereas if both injurers and victims can take precautions ("bilateral precaution"), then negligence or contributory negligence rules need to be used to achieve an efficient outcome, otherwise one or other party will have little incentive to take precautions.

To what extent can regulators and courts and observe these precautions? If precautions are non-observable, then a negligence regime or contributory negligence rule (where the level of precaution a party takes is examined by the court to determine their liability) will not be feasible, as there will be no way to verify whether the negligence rule was broken or not.

Can precautions be taken only during field trials/commercial release, after regulatory approval is granted, or are there also precautions that can be taken in the research or project selection processes? In the former case, firms will have little incentive to take precautions without some form of liability. The latter precautions, if observable, may factor into the regulatory approval decision - and so firms may face incentives to take such precautions so as to increase the likelihood of gaining approval even if they do not bear liability for damages. If they are not observable (or only some are observable), then there could be a moral hazard problem, where firms will not take enough of such precautions because the regulator would not take them into account (since it cannot observe them), and so the regulator will rationally refuse to approve some projects that could be desirable because it knows that firms will not take sufficient precaution.

Are different types of precaution needed to reduce the risks from different types of accident? For example, do precautions used to reduce the risk of property damage also reduce the risk of environmental harm? If so, then the ineffectiveness of tort liability against environmental damage may be less important, as providing incentives to reduce the risk of property damage will also reduce the risk of environmental damage, though not to an efficient level.

Answers to these questions, and so too the optimal liability regime, depend fundamentally on empirical questions.

A number of precautions are possible for reducing the risks of GMOs, and most of these are undertaken by injurers. For any type of GMO, resources spent on laboratory research and medical or field trials will provide information to researchers and reduce the chance that an organism will have undesirable consequences. For genetically modified plants, many of the potential accidents result from hybridisation of GMOs with non-GMO plants. These risks can be reduced by biological barriers, which reduce the chance of cross-fertilisation between species by preventing fertilisation, temporal barriers, which design GMOs to flower at different times of year from surrounding crops, and spatial barriers, which separate GMO crops from other plants with a common pollinator (Cohen, 2000). Maintaining distances between GMO and non-GMO crops also reduces the risk of contamination. Finally, victims can take some precautions by monitoring, and so noticing any contamination early, before serious harm is inflicted.

The efficient precaution level depends on the cost of precautions and their effectiveness in reducing accident costs. The total cost of undertaking a GMO project includes both the costs of precautions and the cost of accidents, so the efficient precaution level is that which minimises the sum of precaution and expected accident costs. This occurs when the marginal cost of taking an extra unit of precaution is equal to the marginal benefit from the reduction in expected accident costs due to the extra precaution.

4.3 Incentives for precaution

The existing economic literature on liability contains a number of important conclusions about the affects of strict liability and negligence on incentives for precaution decisions. The conclusions depend on the answers to the empirical questions discussed above. Under a particular set of assumptions[3], it can be shown that both negligence and strict liability (with a contributory negligence defence if precaution is bilateral) will provide incentives for injurers and victims to take choose efficient precaution levels.

Without liability, injurers would choose to take no precaution, because they do not bear the cost of accidents. If injurers do bear some accident costs, then they will still choose to take some precautions, but this will be less than the efficient level. Thus, some form of liability is needed to shift accident costs onto injurers in order to give them incentives to take sufficient precaution.

Under strict liability, injurers are liable for accident damages, and so choose a level of precaution that minimises the sum of precaution costs and expected accident costs – which is

[3] All accident damage falls on victims, all parties are risk neutral, there are no legal or administrative costs, liable parties are liable for damages equal to the amount of harm caused by accidents, all such liability claims will be paid in full (ie no bankruptcy risk), all victims will file lawsuits, these suits are costless and there is no uncertainty in the outcome of cases.

the efficient level. If victims can also take precautions, then the outcome will be efficient only with a contributory negligence rule, which will provide incentives for victims to take efficient precaution so as to avoid liability.

Under negligence, injurers are liable for accident damages only if negligent, and so will choose to take the efficient precaution level in order to avoid having to pay accident costs. Negligence is still efficient if there are bilateral precautions, because victims will bear residual liability and so act to minimise their precaution and accident costs, which means they will take the efficient level of victim precaution.

Note however that though both systems can lead to efficient precaution decisions, the outcome is not the same: injurers bear accident costs under strict liability, while victims bear these costs under negligence. This provides an explanation for why biotech companies favour negligence, and environmental groups and organic farmers favour strict liability: people prefer the policy system that favours them. This also has an important impact on which investment projects GMO firms will wish to run.

Additional complications can mean that strict liability and negligence need not both lead to efficient outcomes.

4.4 Project selection

While precaution is the main focus of the economics of liability, the efficient outcome may depend not only on the level of precautions taken, but also on the level of activity – on how many and which GMO projects occur. This has not been considered in the New Zealand GMO liability debate so far. An ideal liability system would provide incentives so that all socially desirable projects run, but only socially desirable projects run, where a project is defined to be socially desirable when its social benefits exceed its social costs. In other words, an ideal liability system would have both efficient precaution levels and efficient activity levels.

Firms wish to undertake investment projects when they are profitable. This means that a firm will wish to undertake a GMO project when the private benefits exceed the private costs. Most of the benefits of a GMO project flow to the firm that undertakes the project through profits. Since injurers do not bear accident costs under negligence, and never bear victim precaution costs, there will be some projects that are profitable but are not socially desirable, and this problem will be worse under negligence, where injurers do not bear accident costs. This provides a strong argument for strict liability unless there is some mechanism that can prevent injurers from undertaking socially undesirable projects.

4.5 Project selection and regulation[4]

One candidate for such a mechanism is regulation. GMOs in New Zealand are subject to a unique regulatory regime, under which firms must apply to the Environmental Risk Management Authority (ERMA) for permission to release a GMO. ERMA is required to take all costs, risks and benefits into account when deciding whether to grant approval, and so will refuse to allow a project to proceed if it is perceived to be socially undesirable.

If ERMA had perfect information, then it would be able refuse permission for all socially undesirable projects, and allow all socially desirable projects through. Under these

[4] The formal economic models that this section is drawn from are detailed in Hutton (2004).

circumstances, injurers and victims would both have efficient incentives for precaution because of liability, and project selection would be efficient, so both strict liability and negligence would be equivalent and efficient. Unfortunately, a variety of complications mean that this equivalence result will not generally hold in practice.

4.5.1 Asymmetric information

First, note that information is imperfect and may be asymmetric: some parties may have more information than others. Firms planning to invest in a GMO project will undertake market research to find out if the project will be profitable and so could have good information, but they may not be able to communicate this information to ERMA in a way that is credible, as ERMA might not be able to verify it independently, or may not have incentives to accurately convey this information. In such a situation, firms have better information about the benefits of a project than the regulator does. ERMA will still observe some information about the true project benefits, and its observation will be positively correlated with the true project benefits. ERMA must use this observed information to decide whether to accept a project or not. As a consequence, ERMA will end up approving some socially undesirable projects or will refuse to approve some desirable projects (or both). This problem will be worse under negligence than under strict liability, because there are more socially undesirable projects that are profitable for injurers under negligence, where injurers do not bear accident costs if non-negligent. In other words, ERMA has a harder time selecting only desirable projects under negligence, because there are more applications for undesirable projects.

4.5.2 Sunk research costs

Second, note that many of the costs involved in a GMO project are irreversible expenditures on Research & Development. Many such costs must be incurred before the project gets to a stage where regulatory approval from ERMA is required, and so are "sunk" (ie irreversible) by the time that ERMA makes approval decisions. Because these costs must be paid regardless of whether ERMA approves a project or not, a rational regulator will not consider these costs when trying to achieve outcomes that are efficient (in a static sense).

The regulator is likely to have poor information about these costs, since it will be difficult for a regulator to observe which of a large firms' costs stem from a particular project without having detailed internal accounting information. Firms could also have the ability to distort the observed costs by cross-subsidising activities within the firm, or by not revealing all overhead or implicit costs attached to the project in question, and may have incentives to do this in order to reduce the apparent costs of the project (and so make regulators more willing to approve them). This means that regulators may not be able to make decisions based on the costs even if they wished to do so (in order to maximise welfare in some dynamic sense).

Thus, firms will wish to undertake projects that are profitable, and will invest in and apply for all profitable projects that they know regulators will approve. Regulators who rationally ignore (or cannot observe) costs that are sunk by the time an approval decision is considered will approve all projects where the social benefits exceed the social costs not yet incurred, which exclude the sunk research costs.

This means that there could be some projects that are socially undesirable (total costs exceed benefits), that are profitable for firms (benefits exceed private costs), and that regulators will allow to proceed (benefits exceed total non-sunk costs). Knowing that regulators will approve them, and anticipating this, firms will invest in these projects, and they will proceed – despite being socially undesirable. This problem will be worse under negligence than

under strict liability, since there will be more projects that are socially undesirable but profitable for firms, since firms bear fewer costs under negligence than under strict liability.

If firms have the ability to commit to some costs, then they may also have a strategic incentive to prepay some of their costs up front before applying for regulatory approval. Because these costs are then sunk when the regulator makes their decision, they will be ignored, which will make the regulator more likely to approve the project. This will make the problem under negligence worse, since it will increase further the ability of the firm to get regulatory approval for profitable but socially undesirable projects.

4.5.3 Imperfect information and sunk costs

Another problem concerns the incentives a firm faces to invest in research and development. Consider the fact that the information a firm has about the risks of a project is often poor until a firm undertakes significant R&D. In other words, firms have imperfect information about the risk of a project when deciding whether to commit to undertaking the sunk research costs, and only observe the risk of the project once these costs are sunk and the research is undertaken. Once the true risk is observed, then firms will choose to make efficient precaution decisions based on these risks because of liability (whether strict or negligence), and the regulator will also observe the true risk when making regulatory decisions.

In such a situation, there is no inefficiency in the (fully informed) regulator's decision, who will ignore the sunk costs, but there will be an efficiency problem in firms' decision to invest: firms are too willing to invest in research. Firms are too willing to invest because they choose to invest in projects based on a profit calculation that ignores victim precaution costs. Firms will investigate when their expected profit (where profit is benefits less private costs) exceeds the research costs, whereas a project is only socially desirable to in when the expected social benefits (benefits less all social costs) exceeds the research costs. Social costs exceed private costs because private costs do not include victim precaution costs, and under negligence do not include accident costs. This also means that the problem is worse under negligence than under strict liability, because under negligence firms will not consider accident costs.

4.6.3 Biased regulation

Another problem occurs if the regulator has some degree of bias in its analysis of projects. In the case of GMOs, an argument could be made for a bias either way. ERMA staff who undertake analysis of applications are generally ex-researchers, since ERMA must hire people who have the necessary technical skills, and so could be overly sympathetic to researchers' perspectives. On the other hand, ERMA as an institution gains few benefits from a successful project but will suffer political fallout from public outcry should an accident occur, so may have incentives to be overly conservative in approving projects.

In their review of ERMA's capabilities, Nahkies et al (2003) suggest that there is a perception of pro-applicant bias by some interest groups, particularly those with ethical or spiritual concerns about GMOs who feel that their concerns have little impact on decisions. However, they also find that applicants believe that decisions are "heavily weighted towards a conservative management and regulation of potential or perceived risk." Thus, it is not clear in which direction any such bias exists, or its magnitude.

If all parties had perfect information, the effects of a biased regulator would be relatively straightforward. If the regulator is biased against projects, then they will only let very

beneficial projects proceed, and these projects will be profitable for firms regardless of the liability system. This means that strict liability and negligence are equivalent if the regulator is biased against projects and information is perfect. If the regulator is biased in favour of projects, then they will allow some socially undesirable projects to proceed. More of these projects will be profitable under negligence, and so firms will apply for and receive approval for more of these projects under negligence than under strict liability, and so strict liability is superior to negligence.

The results are more complicated if we acknowledge that regulators have imperfect information, and that applicants generally have better information than regulators. Regardless of the direction of bias, a regulator will allow a wider set of projects through under strict liability than under negligence. This occurs because the firm sends an informative signal to the regulator (that it thinks a project is profitable) by applying for the project. This signal is a more positive signal of the merits of the project under strict liability than under negligence, since projects are more profitable under negligence than under strict liability. Since regulators always prefer projects that are more socially valuable regardless of the direction of their bias, their approval requirements will always be more restrictive under strict negligence than under strict liability, because they receive better information from observing that the firm wishes to undertake the project.

If regulators are biased against projects, then strict liability dominates negligence. This somewhat counterintuitive result occurs because regulators biased against projects will set overly restrictive approval requirements, but the restrictions will be more relaxed (and so closer to the efficient level) under strict liability than under negligence, because regulators know that a project the injurer wants to run is more likely to be socially desirable under strict liability than under negligence.

If regulators are biased in favour of projects, then the regulator sets overly lax approval requirements. While the approval requirements will still be larger under strict liability than under negligence, it is not clear which policy regime will lead to higher social welfare. If the bias is large enough, then the regulator will accept all projects that applicants will wish to apply for, and so strict liability is better than negligence because it causes firms to apply for fewer socially undesirable projects. If the bias is small enough, then strict liability is also better than negligence because the welfare gains from injurers applying for fewer socially desirable projects outweighs the welfare costs of the bias. However, for intermediate values it is possible that negligence could be better than strict liability, because the regulator accepts overly lenient approval requirements, and these are more lenient under strict liability than under negligence.

4.6.4 Evidentiary uncertainty

While strict liability only requires plaintiffs to prove that the defendant caused an accident that inflicted harm, negligence also requires proof that the defendant did not take a reasonable level of precaution. While this reasonable level of care should be the efficient level, in practice it is often difficult for courts to calculate this level, or to accurately observe the level of precaution taken by firms. This adds a further problem to negligence liability systems, since taking the efficient level of precaution no longer guarantees avoidance of liability, so firms may not have incentives to take precaution decisions.

The effect of evidentiary uncertainty on precaution levels depends on the size of the uncertainty involved. The larger the level of uncertainty, the smaller is the marginal

reduction in the probability of being found liable for any given increase in precaution. This means that if the uncertainty is small enough, firms will choose to take excessive precaution in order to increase the probability of avoiding liability. But if the level of uncertainty is large enough, the injurer will under-protect, because the cost of higher expected damages from reducing precaution is low relative to the gain from bearing a lower precaution cost. However, firms will never choose a precaution level that leads to them bearing higher expected total costs than they would bear under strict liability, since they can never do worse than being liability with probability one.

This effect on precaution level will also have an impact that projects firms wish to undertake. In particular, it could potentially reduce the number of socially undesirable projects that firms wish to undertake, and so could increase social welfare relative to negligence with no uncertainty. However, the only projects that firms will choose not to run because of this uncertainty will be projects that they would not run under strict liability, so negligence with evidentiary uncertainty is still inferior to strict liability.

If victims can also take precautions to reduce accident risk, then strict liability needs a contributory negligence defence in order to provide incentives for efficient victim precaution. In this case, the problem of evidentiary uncertainty also applies to contributory negligence rules under strict liability, so victims may not have incentives to choose efficient precaution decisions. As above, if the uncertainty is small enough then victims will take excessive precaution, while if uncertainty is large enough victims will take insufficient precaution. While victims do not make project selection decisions, their precaution decisions will effect what projects firms wish to undertake: if victims take excessive precaution, then the expected cost of accidents is less for firms, so they may wish to undertake more projects than before, and to take more or less precaution (depending on whether injurer and victim precaution choices are complements or substitutes, ie whether victim precaution makes injurer precaution more or less effective, respectively). The optimal policy in this case is ambiguous: it is possible that negligence could be superior to strict liability with contributory negligence, or vice versa, depending on the relative levels of uncertainty and the specific functional forms of the relative effectiveness of precautions. It might be the case that the better policy is to place the negligence rule on the party whose precaution is less uncertain, but this is not certain.

4.6.5 Externalities

One problem with the arguments above is that they have assumed that GMO projects caused no externalities that cannot be internalised through use of liability, and that all benefits from GMO projects were appropriated by the firm through profits. To be more realistic, we should consider the possibility of other externalities, both positive and negative. Possible positive externalities include gains to society from knowledge spillovers, tax payments, consumer surplus from GMO products or by reduction of existing negative externalities (such as by reducing the need for pesticides). Additional negative externalities include the costs of accident types for which liability will not be an effective instrument, particularly for widespread environmental damage. It is unclear which of these factors dominate, and so whether net externalities (ie those that we cannot internalise through use of liability) are positive or negative.

Suppose that these net externalities are negative. In this case, strict liability and negligence are equivalent and efficient with a perfect regulator (and ignoring any research cost problem), since the firm will apply for all socially desirable projects (and some others), while the

regulator will be able to reject all socially undesirable projects. However, if regulation is imperfect (or non-existent) then strict liability will dominate negligence because firms apply for fewer socially undesirable projects under strict liability.

Now consider the more complex case where net externalities are positive. First note that if these externalities are large enough, then there are socially desirable projects that are unprofitable for firms, while if the externalities are small enough then there will be profitable projects that are socially undesirable. This means that the outcome can be inefficient even with a perfect regulator because though the regulator can refuse approval for the latter projects, it cannot force firms to undertake the former projects. This inefficiency will be worse under strict liability than under negligence, since projects are more profitable under negligence, and so there will be fewer unprofitable but socially desirable projects.

Unfortunately, the outcome is ambiguous if there is imperfect (or no) regulation, because in these circumstances the regulator can no longer prevent all socially undesirable (but profitable) projects from running. Negligence will tend to be superior if the positive externalities are larger, while strict liability will tend to be superior if the positive externalities are small (or if there are many projects with high accident risk).

The following table summarises these results. ("Imperfect regulation" considers the case of regulation in the presence of asymmetric or imperfect information, sunk research costs or similar problems, and where ≥ signs indicate weak dominance relationships and = signs indicate equivalence).

Optimal liability regime with externalities			
	Positive externalities	No externalities	Negative externalities
No regulation	NL ≥ SL or NL ≤ SL	SL ≥ NL	SL ≥ NL
Perfect regulation	NL ≥ SL	SL = NL	SL = NL
Imperfect regulation	NL ≥ SL or NL ≤ SL	SL ≥ NL	SL ≥ NL

4.6.6 Limited liability and the judgement-proof problem

A final problem with liability occurs because of the limited liability of companies (and individuals). If a company undertakes an activity that causes an accident, it cannot be forced to pay more in damages than the total assets of that company. In other words, firms are "judgement-proof" from accidents whose damage exceeds the assets of the company. Since firms know this, they have insufficient incentive to take precaution against such accidents, since they know that they cannot be made to bear all of the costs, regardless of their precaution choice. This problem is much worse under strict liability than negligence, since under negligence firms do not bear accident costs if they take sufficient precaution and so the judgement-proof problem does not arise.

There are some mechanisms such as compulsory insurance that may mitigate this problem, and these are discussed below, but these are likely to provide imperfect solutions. This severity of this problem (and so the strength of the argument in favour of negligence liability) depends on the probability of accidents that cause large amounts of damage occurring: the lower probability of such accidents, the weaker the argument for negligence.

4.6 Problems with tort liability

There are a number of problems inherent in any tort liability regime. Some of these favour one form of liability over another, while others do not.

4.6.1 Legal costs

All liability regimes rely on individuals or firms pursuing and continuing lawsuits against injurers, but the legal costs involved may deter them from doing so. This is problematic, because if victims do not pursue lawsuits then there is insufficient incentive for injurers to take precautions, and so liability regimes will not lead to efficient outcomes. This underlies all tort systems, but may be a bigger problem under a negligence regime than under strict liability, where victims have a higher probability of winning any given case and so are more likely to undertake such a suit.

However, legal costs can work both ways: high injurer legal costs also provide incentives for injurers to take higher (and possibly inefficiently high) levels of precaution in order to reduce the probability of accidents. The impact of legal costs on efficiency thus depends on which of these effects dominates. It is likely that the problem of victim legal costs deterring lawsuits is a more important concern, as large defendants may be more able to bear legal costs, and may gain reputational advantages from aggressively defending suits and so deterring subsequent lawsuits. This supports the argument for strict liability over negligence (to encourage victims to undertake lawsuits), and for punitive damages (so as to increase the expected cost from accidents, since this cost will be too low if victims often do not undertake lawsuits).

The effect of legal costs will however depend on who actually bears these costs, rather than who incurs the costs. In other words, their effect depends on whether plaintiffs are awarded costs in successful suits and defendants in unsuccessful suits. A successful defendant is usually awarded a costs payment, but it seems likely that for many GMO-related suits that defendants may have high legal costs while being prosecuted by small farmers or firms who may not have sufficient assets to cover these costs, and so defendants may be unlikely to actually recover their true costs even if they are awarded costs. It is less common for successful plaintiffs to be awarded costs in addition to damages. However, even when "costs" are awarded, they rarely cover the actual legal costs incurred. This suggests that legal costs are largely borne by the party that incurs them.

It is also possible that legal costs may be less significant than is sometimes suggested, since after initial test cases establish precedent, it is likely that many later disputes can be resolved by settlement without recourse to expensive legal action. Large firms and insurers often prefer settlements to lawsuits, because they have a smaller negative impact on firm reputation, and provide greater certainty than trials.

Legal costs are also real costs to society, and so an efficient liability system should also attempt to minimise legal costs, as well as precaution and accident costs. Legal costs are also likely to be lower per case under strict liability than negligence, as plaintiffs have a lower burden of proof and so have fewer things to establish. However, fewer lawsuits will occur under negligence, and so it is unclear whether aggregate legal costs are lower under strict liability or negligence.

4.6.2 Causation

Under any liability regime, accident victims must prove that they suffered harm, and that this harm was caused by a particular GMO and a particular injurer. This difficulty will cause victims to undertake too few court cases, and so injurers will take insufficient precaution. However, this problem may be solvable through use of punitive damages: if damages are greater than the harm inflicted by an accident, this could lead to incentives for efficient precaution.

Problems with causation are inherent in all tort liability regimes, whether negligence-based or strict liability: all such regimes require the plaintiff to prove that the defendant caused the harm they have suffered. It is also unclear whether the problems of causality are any greater for GMOs than for other areas where tort liability is used, such as linking cancer to chemicals or smoking. However, negligence liability entails the additional requirement to prove that a duty of care was breached in negligence liability, so it will be more difficult for plaintiffs to win cases so they may not undertake enough cases. Thus, there is an argument for strict liability over negligence if punitive damages are infeasible.

4.6.3 Limitations

Some parties also have concerns about the implications of the Limitation Act 1950 for damages from GMOs, as harm may not manifest for a considerable amount of time after an accident has occurred. The Limitations Act normally requires that legal actions be commenced not less than 6 years after an accident occurs (or 2 years for personal injury), which could rule out claims for damages where harm was not discovered within the 6 years. It is possible that under the status quo this time limit will be held to commence from discovery of harm rather than at accident date, but this is not clear (Todd 2001, p19). If this discoverability principle is not applicable, then there should clearly be legislation to require it – it would be inefficient (and unjust) for claims to not be allowed because of a time limit when the harm in question may be inherently latent, because injurers would not have incentives to take precautions for accidents that will not manifest until after the period of limitations. Failing to support the discoverability principle would lead to insufficient precaution by injurers.

4.7 Who should bear liability?

Much of the discussion on liability regime design is centred on a highly simplified characterisation of the relevant parties involved. Such discussion generally considers the relevant parties to be an "injurer", generally assumed here to be a GMO firm, and a "victim", such as a farmer whose land is near where a GMO crop is grown.

In practice, the situation is not so simple: a more realistic characterisation would acknowledge the existence of both GMO research & development companies (including Crown Research Institutes and Universities), who would own the intellectual property right to a particular GMO, and also GMO users, such as farmers who plant GMO crops. There may also be manufacturers who produce GMO medicine or seeds under some contract with the research company. These groups face different types of precautionary activities, access different information and face different incentives, which may lead to a number of principal/agent problems. In any contractual relationship between these groups, it is likely that monitoring will be imperfect and that parties will not be able to contractually specify all the actions that the parties will take.

These imperfections must be considered when designing a liability regime. For example, it will not be efficient to hold researchers strictly liable for all accidents if precautions are non-

contractible and are mostly controlled by farmers: researchers could not force farmers to take precautions (and farmers would not have incentives to take precautions if researchers are strictly liable), so channelling strict liability to researchers would lead to excessive precautions by researchers and insufficient precaution by farmers, while a negligence regime for both party might lead to more efficient precaution decisions by both parties. Given that there are likely to be many more farm companies than researchers, transaction and administration costs from performance bond or compulsory insurance schemes are likely to be higher if placed on users than on researchers. Researchers are likely to have more information about many types of risks than users, while users may have better information about other types of risks or potential financial benefits.

For many accidents (particularly those that cause widespread environmental damage) there are likely to be large numbers of victims. It only makes sense to treat victims as a single party for environmental accidents to the extent that class action suits are feasible (which can involve high transaction costs if many parties are involved) or if government will take civil actions. If such suits are not possible then individual victims will face little incentive to undertake suits against injurers, and so injurers may take insufficient precaution.

The effects of multiple injurers and victims will depend on the nature of the liability regime, and in particular on how liability is allocated between these parties. The main question is whether liability should be channelled to a particular party or shared between parties, and in the latter case on whether liability is joint and several or proportional.

In some situations, it may be desirable for liability to be channelled to the injurer best able to bear risk. This party could then spread the cost of risk to other injurers and consumers through contractual relationships (ie through the prices of their outputs and their willingness to pay for inputs). Some injurers will be better able to bear risk than others: they may be less risk averse, they may have control over more important precaution decisions, they may be able to monitor and enforce the precaution levels of other injurers, they may have better access to insurance (such as through lower transaction costs or fewer moral hazard problems), they may be well-placed to spread the costs of liability to other parties through contractual arrangements or they could have better information than other injurers.

It would be very difficult for legislators to determine which injurer would be best suited to bear risk, because such a decision would require detailed information, because the best-suited injurer might be different for different projects and activities, and because the risk allocation decisions may in turn affect the market structure. An alternative means of channelling liability to the injurer most able to bear risk could be to assign liability to the holder of the intellectual property right on the GMO, and then allow injurers use negotiation and contracts to allocate the IPR to the party best able to bear risk. However, this may fail to deliver efficient precaution in the presence of limited liability: injurers might allocate liability to the party with the least assets (and so most likely to be judgement proof, and so shift risk onto victims) rather than the party best placed to bear risk. Thus, channelling liability to a particular party is problematic.

If liability is not channelled to a particular party, then there must be some rule that determines how liability is allocated between parties. One possible rule is “joint and several” liability, which can be used in conjunction with either strict or negligence liability regimes.

Under strict liability with a joint and several liability rule, each injurer can be held liable for the entire damage caused by an accident. Any party that could take precautions (regardless of whether they did take precautions or not) could be found liable for the entire cost of an accident if the victim sues them.[5] It is likely that victims would tend to sue injurers with the most assets (or where causation is easier to prove), and so the highest probability of collecting damages. This suggests that if injurers have different levels of assets, high-asset injurers could face excessive incentives for precaution (and may not be willing to undertake socially desirable projects) and low-asset injurers could have insufficient incentives for precaution, because both know that the high-asset injurer is more likely to be sued if an accident occurs.

Under negligence with joint and several liability, individual injurers can be held liable for the entire accident costs if they take less precaution than their legal standard of precaution (ideally set equal to the efficient level). Injurers will thus have strong incentives to avoid being negligent: by doing so they avoid the possibility of being held liable for the entire accident. There could still be incentives for insufficient precaution, but this is less likely than under joint and several and strict liability. Furthermore, there will be no incentive for excessive precaution (except to the extent that there is evidentiary uncertainty surrounding precaution levels).

Thus, if liability is joint and several, then negligence will be superior to strict liability (unless evidentiary uncertainty is high[6]) because it will lead to more efficient precaution choices.

The alternative to joint and several liability is "proportional liability", where each injurer is liable for a proportion of the cost of an accident based on the proportion of their contribution towards the accident. Under negligence, injurers would be liable for a proportion of damages based on how far their precaution deviated from the efficient level. This could provide efficient incentives for precaution as long there is little evidentiary uncertainty. The interpretation of proportional strict liability is more difficult to determine than the negligence case, but injurers would be liable for a proportion of damages related to the proportion of the accident they caused.[7] This will generally lead to parties choosing more efficient precaution levels than under joint and several liability, as the damages each firm faces will be closer to the social cost that their actions cause.

Proportional liability could lead to better precaution decisions than joint and several liability, but will have higher legal costs, as lawsuits will have multiple defendants and require courts to reach judgements about the proportion of liability that each party bears.

An important aspect of the Hazardous Substances and New Organisms Act as it stands is that once a particular GMO has been approved for commercial release, any party may release it. Initially, release will be determined by the holder of the intellectual property right over a particular GMO, who will then presumably license its access to individual users and farmers,

[5] Note that once a victim successfully sues a particular injurer and receives compensation, they cannot then sue another injurer and so receive more compensation than damage done.

[6] If evidentiary uncertainty is high, then negligence could lead to excessive or insufficient levels of precaution, because taking efficient precaution does not guarantee that liability will be avoided.

[7] For example, injurer's could be liable for a proportion of damages based on what percentage their efficient precaution costs are of total injurer precaution costs: if accident damages are 1000, the cost of precaution if all injurers took efficient precautions equals 100, and the cost of the efficient precautions by a particular injurer was 30, then that injurer would be liable for accident costs of 300 if an accident occurs.

and such a licensing contract may allow for some monitoring. Thus, it may be feasible in the short-term to make the holder of the intellectual property right liable, as they have some control over all releases. However, in the longer term, intellectual property rights expire, and after expiry any company would be able to produce and release a particular GMO. Thus, the long-term consequences of any liability regime need to be considered, such as whether it is efficient to make the original researcher liable for any damage from competing producers, while noting that it could be difficult to trace damage from a GMO released by multiple parties back to a particular injurer.

4.8 Insurance

Insurance is the practice of allowing risk-averse parties who bear risk to sell that risk to other parties. Accident insurance can have three effects: it decreases the incentive for parties to take precautions to reduce risk (moral hazard), but it increases welfare by moving risk away from risk-averse parties (or pools that risk), and provides compensation for victims of accidents where this would not have happened due to bankruptcy.

4.8.1 Who should bear liability when insurance is available?

Insurance can generally be purchased either by victims to cover their own losses if an accident occurs ("first party" insurance, such as fire insurance), or by injurers to cover damages they are liable for ("third party" or "liability" insurance, such as malpractice insurance). Without insurance (and where courts can observe precaution), residual liability should generally be placed with the party (injurer or victim) that is less risk averse. In a situation of full and actuarially fair insurance, whether residual liability should be placed on injurers or victims depends on whether transaction costs are lower for first party or third party insurance. Since in the context of GMOs it is likely that there will be fewer and larger injurers than victims, it is likely that transaction costs would be lower for third party insurance, and injurers are likely to be less risk averse than victims. This would tend to favour an argument for liability insurance, and so strict liability. However, transaction costs could be lower for first party insurance, since this avoids courts and legal costs, which would favour negligence.

4.8.2 Moral hazard

Moral hazard is a general term describing situations where the creation of a contract may provide incentives for one party to take undesirable behaviour. Moral hazard in insurance occurs when insurers are not able to perfectly monitor the precautions taken by insured parties, since insured parties then face insufficient incentives to take precautions. If insurers are able to monitor precautionary behaviour[8] ex post, then they can stipulate in the insurance contract that cover is not provided unless the efficient level of precaution is taken. Insurers would have incentives to do this, since bearing all risk means they wish the efficient level of precaution to be taken to minimise this risk. If insurance contracts have such clauses, there will be no moral hazard problem as long as insurers can perfectly observe precaution levels ex post.[9] However, if monitoring is not possible or is imperfect, then there will still be some

[8] Technically, being able to monitor behaviour is not enough – in most cases this behaviour must also be contractible. In other words, behaviour must be able to be clearly measured and defined in contracts, and that the observed level can be verified in court: in order for monitoring to be of value, insurers must be able to cancel coverage should precaution be insufficient. In order to do this, they must be able to stipulate what circumstances will cancel coverage in the insurance contract, and then verify that the actual precaution met these circumstances in court should the insured party challenge the cancellation of coverage.

[9] If injurers may be judgement proof, then ex ante insurer monitoring may be required under some circumstances in order to eliminate moral hazard.

moral hazard, but social welfare will still generally be higher than if liability insurance was banned (Shavell, 1982, 2000).

The magnitude of the moral hazard problem will depend on both the nature of available precautions possible and the ability of insurers to observe (and so contract on) precautionary behaviour by insured parties.

Some precautions will be relatively easy to observe, such as laboratory procedures, crop distances and requirements for clinical and field trials. Others, particularly technical issues such as inclusion of the efficient levels of biological and temporal barriers could be difficult to observe, but presumably insurers will hire staff with technical expertise to monitor these to some extent. Note that for a negligence rule to work, we need courts to be able to observe precaution, so presumably insurers can also observe precaution.

4.8.3 Uninsurability

There have been concerns from many parties that insurers may not be willing to offer cover for harm from GMOs. If there is limited cover available, then GM firms will be less willing to invest in GM projects (both socially desirable and undesirable) than if they were able to insure, and victims are unlikely to receive full payment of large damages awarded to them because of limited liability.

There are a number of markets where insurance is unavailable or incomplete, because insurance companies are not willing to offer insurance (or equivalently, to offer it at prices that firms or individuals are willing to pay). These markets are generally those where insurance performs poorly as a risk management device.

The standard requirements for well functioning and actuarially fair insurance markets are:

- There should be good information about the probability distribution and magnitude of accidents.
- This information should be symmetric between insured and uninsured parties, so there is no adverse selection problem.
- There should be no moral hazard problem.
- The maximum level of payout should not be too large.
- Insurance claims should be independent

(for example, see Barr 1993)

The major concern about insurance for GMOs is that many of these requirements for efficient insurance are not met, and so it is likely that the market for insurance for damages from GMOs will be incomplete.

There is currently very little empirical information available about the risks posed by GMOs. Some data can be drawn from the historical record of GM crops can be drawn from use in North and South America (particularly USA and Brazil), but this is from a relatively short period and contains few damages claims. There are no activities that are clearly similar to GM use from an insurance perspective whose claims data could be used instead. This means that the probability of an accident occurring and the likely damages that an insured injurer would be liable for are unknown, and expectations of these may be highly inaccurate. This makes actuarial analysis difficult, and so insurers may not be willing to offer insurance except at very high premiums.

Insurers can be described as being "ambiguity averse" – when they do not know the true probability distribution of accident risk, they will charge insured parties a higher premium to compensate for this uncertainty. [10]

Insurer ambiguity aversion is important for the case of GMOs because insurers do not know the probability distribution of GMO accidents. This means that insurers may not be willing to offer actuarially fair insurance even if risk neutral, and if the ambiguity is large enough then a market for GMO insurance may not exist.

The problem of incomplete information will be more severe where GMO firms have more information about their risk than injurers. In these cases, there may be an adverse selection problem, whereby insurers have to set premiums high enough to cover losses from high-risk firms, which tends to drive low-risk firms out of the market. In other words, actuarially fair insurance may not be available for low risk projects if insurers cannot distinguish between high risk and low risk projects, but firms can do so. However, insurers offering insurance for GMOs will presumably hire experts in GM risk analysis, so firms might not have much more information than insurers about risk.

Moral hazard, as discussed above, will also raise the cost of insurance. While insurance will still be "actuarially fair" given the higher level of risk caused by moral hazard, it will cost more than it would in the first-best efficient outcome with no moral hazard.

The size of potential damages from an accident will not necessarily reduce the availability of insurance. The international reinsurance industry is capable of providing cover for very large damage claims if the probability of occurrence is well known – though the premiums required will be accordingly high.

Some have argued that insurance may not perform well for GMOs because of correlation between damages claims, since a single accident may cause harm to multiple victims. However, the occurrence of accidents is likely to be uncorrelated: if a GMO crop in one area happens to contaminate the crop of a neighbour, then this does not increase the likelihood of another crop contaminating another farm[11]. Each accident causes harm and damage payments to multiple parties, but these could be aggregated and considered as a single accident with harm equal to the aggregate harm suffered by all victims. In many cases multiple victims from a single accident may take class action suits against a single injurer, so damages claims may also be aggregated in practice. Thus, the effect of multiple victims is simply to increase the effective size of damages – and the size of claims is not necessarily a barrier to the availability of insurance. Larger effective size does however increase the need for reinsurance and so the transaction costs involved in providing insurance cover.

On the other hand, an argument can be made that insurers' expectations of payouts may be correlated across policies. Given imperfect information and ambiguity about the risks posed by GMOs, if a particular GMO turns out to cause an accident, that may cause insurers to update their beliefs about the risk of GMOs in general (or about the risk of a particular

[10] Kunreuther, Hogarth and Mezaros (1993) surveyed actuaries, underwriters and insurers, and found that they will add an additional cost above the expected value of losses when there is ambiguity regarding the probability or magnitude of payouts.

[11] Arguably there could also be some common element across organisms that effects the likelihood of accidents. For example, if particular climate or weather conditions affect the probability of an accident, then accidents will be correlated.

category of GMO products, e.g. modified soy crops), and so could cause their expectations of the risk of other GMO projects to rise. If this is the case, then if one GMO project causes an accident then this increases insurers' expectation of the probability of having to make payouts for accidents from other projects, and so effectively the expected of payout of policies for different projects may be correlated. This would have the same effect on insurance as if accidents were actually correlated.

Payouts for damages could also be correlated if legal precedents stimulate further litigation and so further payouts (eg a landmark court case in favour of victims stimulates other victims to sue for similar cases, as has occurred for tobacco cases in the USA).

Correlation between GMO payouts should only pose a problem for the insurance industry if these payouts are also correlated with the performance of capital markets. If this GMO risk is uncorrelated with market performance (as seems likely), then GMO insurance contracts have no systematic risk, and in theory insurers could diversify away the effects of non-systematic risk as long as the GMO risk is a small enough proportion of global capital markets. Thus, correlation of claims might not present a major problem for GMOs. In practice insurers are often not able to diversify away all effects of non-systematic risk as capital markets are imperfect, so correlation may still increase the premiums insurers require to cover GMO accidents. However, even if GMOs were correlated with capital markets, the effect of this would merely be to increase the required premiums, which need not imply an efficiency problem.

There is some evidence suggesting insurers may be unwilling to offer cover for many GMO-related activities. The Law Commission notes informal conversations with the Insurance Council of New Zealand, which suggest insurers would be unwilling to offer cover because of inadequate information (Law Commission 2002, p29 para 109), and Swiss Re suggests that insurance cover may be limited, but there has been limited public comment from the insurance industry thus far.

However, the problem of uninsurability may be overstated. Correlation and accident size are not likely to be major problems for global insurance markets, and ambiguity will fall over time as more information becomes available about the probability distribution of risks. Thus, uninsurability may be a temporary problem that could slow the growth of GM technology, rather than a long-term issue.

Another problem exists for insuring GMOs in that insurance typically only provides cover for the period in which the premium is paid. If companies cease to pay premiums (due to bankruptcy or ceasing to use GMOs), then insurance cover will cease even though the potential for harm may continue. One possibility would be for insurance contracts to cover harm caused during periods when premiums are paid, regardless of when it is actually discovered. This could be problematic however in that it may not be possible to determine exactly when the accident occurred, particularly if considerable time has passed before the harm is discovered.

4.9 Bankruptcy and compensation instruments

As discussed above, a major problem with tort liability systems is that injurers may not be able to be held liable for full accident damages, and so injurers make take insufficient precautions. There are two main reasons why this may occur.

First, the injurer that undertook the activity that caused an accident may no longer exist as a legal entity when the accident damage is discovered (generally due to bankruptcy or winding up a venture company). This could be a particular problem with GMOs because of the potential for a long time lag between use and damage. If injurers know that this may occur, then they know there is a positive probability that they will not have to bear liability for accidents, and so do not have incentives to take sufficient precaution.

Second, the level of harm done to the victim may exceed the assets of the injurer, and so the injurer may go bankrupt because of limited liability rather than pay the full cost of the damages, leaving the injurer "judgement-proof". In bankruptcy, winners of tort actions have financial claims with the same status as other unsecured creditors, and will usually not receive the full damages payment they are awarded. Because of bankruptcy risk, injurers know that there is a chance that they will not have to bear the full cost of the risk of their actions, and so have incentives to take fewer precautions than is optimal.

The problem of bankruptcy will be particularly important if firms with significant assets are able to create subsidiary companies in which hazardous activities (such as GMO release) are carried out. Firms could create such subsidiaries and pay out the profits to the parent company, leaving the subsidiary with very few assets. If a major accident occurs, then the subsidiary may be unable to pay the damages and go bankrupt, but the parent company will be unharmed, unless the courts are willing to reach through to the parent company to apply damages. Thus, if activities are carried out by small limited liability subsidiaries, then the problem of insufficient precaution will be worse, because there will be a higher probability that any given accident will cause more damage than the injurer has assets, and so a higher probability that the injurer will be judgement-proof. Alberini & Austin (1999) find some evidence that firms respond to imposition of strict liability regimes by reducing their business sizes, and so their asset levels.

While firms acting in shareholder interests will still have an incentive to reduce the probability of high damage accidents, they do not have an incentive to invest in precautions that reduce the magnitude of damage of an accident if that accident would already bankrupt the company, as shareholders would bear all of the costs of precaution but achieve no savings in the event of an accident.

The problems of bankruptcy are much worse under strict liability than under negligence, because injurers must always bear accident costs under strict liability, but will only do so under negligence if they are negligent. Thus, injurers may still take sufficient precaution under negligence, because this will allow them to avoid liability. If strict liability was to be adopted, then we may want some mechanism to try and mitigate the judgement-proof problem. A range of such mechanisms are considered below.

4.9.1 Compulsory insurance

One way of mitigating the judgement-proof problem under strict liability is a regime of compulsory insurance. Such a mechanism was suggested by many submitters to the Royal Commission, and is commonly used for many hazardous activities (such as compulsory 3rd party auto insurance). A compulsory insurance regime would require some (or all) liable parties to purchase insurance if they wish to release a GMO.

The effect of a compulsory insurance regime (under strict liability[12]) would be to force injurers to bear the full cost of the risk their accident imposes. Insurance premiums would be based on the risk of an activity, and so insured parties would still bear the cost (but not the uncertainty) of their activities by paying premiums. These premiums would be paid before the activity could cause an accident, and so limited liability would not affect the ability to pay premiums. As discussed in 4.8.2, insurers will generally monitor the behaviour of insurees, and will deny coverage if insufficient precaution is taken. Because of this, injurers would face precaution incentives equivalent to those of a negligence regime[13]: if an injurer took less than the efficient level of precaution, the insurer would observe this and so insurance cover would be invalidated, while the injurer would have already paid the cost of the premium. Thus, injurers would generally choose to take efficient precaution levels.

Compulsory insurance will however add to the costs (both private and social) of the GMO industry because of the transaction and administration costs involved in running insurance. Without compulsory insurance or the judgement-proof problem, risk-averse firms will choose a level of insurance by balancing the transaction costs of insurance against the benefits from transferring risk to insurers (which is a social gain). With the judgement-proof problem, they will purchase insufficient insurance. However, requiring compulsory insurance could force firms to purchase excessive insurance, since the gains from that insurance (from shifting risk to less risk-averse parties, and from mitigating precaution decision problems caused by judgement proofing) might not outweigh the transaction costs of providing insurance for all injurers.

The performance of a compulsory insurance regime depends fundamentally on what level of insurance cover is available. If insurance cover is available for most types of projects that applicants wish to run, then such a regime may mitigate the problems created by judgement-proof injurers. If, on the other hand, insurance cover is highly limited or expensive because of uninsurability problems, then a requirement for compulsory insurance will effectively ban a wide range of GMO projects.

This poses the question as to whether projects that injurers wish to undertake without insurance, but which they will not undertake with compulsory insurance (because of the cost of insurance) are necessarily socially undesirable.

There are many reasons why insurance markets might be unwilling to provide insurance for socially desirable projects. For example, there may be a delay in design of financial instruments for covering GMO risks, or a lag in information between the GMO industry and the insurance industry. This would lead to a period in which GMO use was effectively banned, though this would be temporary. If GMO damages retain significant ambiguity beyond the medium term, then it is possible that insurers may still refuse to insure such projects because of ambiguity aversion. If injurers are less ambiguity averse than insurers (or if injurers have better information about risks than insurers and so suffer less from ambiguity), then there could be socially desirable projects that insurers would not be willing to cover. Finally, if insurance entails a moral hazard problem, then compulsory insurance could raise the costs of insurance such that some injurers would not run some projects that

[12] The case for compulsory insurance under negligence is much less convincing. Under negligence, injurers will generally avoid liability by taking sufficient precaution, and so need not purchase liability insurance.
[13] Ignoring the problems of imperfect insurer monitoring, a strict liability regime with compulsory insurance is fundamentally very similar to a negligence regime, but where injurers must still bear the cost of accidents risk.

would be socially desirable if efficient precaution levels were taken. In other words, compulsory insurance may effectively ban some socially desirable projects.

Since the benefits of compulsory insurance come from reducing the probability of bankruptcy, the benefits from introducing compulsory insurance are higher when bankruptcy is a serious problem (ie when in there is a high probability that accident damage exceeds injurer assets). Imposing compulsory insurance has two types of costs. First, it reduces welfare because of the transaction costs of insurance (and possibly moral hazard costs) on projects that run. Second, it reduces the profits that injurers receive from projects and so may lead to some projects not running that would have been socially desirable without compulsory insurance, which reduces welfare. Given these, compulsory insurance will have lowest benefits and highest costs for projects where there is a low probability of large accidents, insurance costs are significant (because of transaction costs or moral hazard due to unobservable precaution), and private benefits to injurers are low relative to social benefits (due to large positive externalities). Many projects may fit these characteristics.

4.9.2 Capped liability

Uninsurability problems may limit the range of projects which risk-averse injurers are willing to undertake, particularly if insurance is compulsory. It has been suggested that one way of mitigating uninsurability problems would be to legislate a liability cap on the damages an injurer (or their insurer) can be forced to pay in the event of an accident. This has been used in several liability situations, particularly for liability for nuclear plants in the USA.

Capping liability would have two effects. First, it would reduce incentives for liable parties to take precautions, because they will not face full accident costs if an accident occurs. This problem would be worse under strict liability, since injurers may still choose to take efficient precaution levels under negligence in order to avoid liability. Second, it could expand the availability of insurance, by reducing insurers' worries about being faced with large payouts, and by reducing the ambiguity faced by insurers about the probability distribution of payouts (by truncating the probability distribution of payouts at the cap).

When considering the effects of capping liability, we must note that parties can enter into capped liability insurance contracts in private markets. There is nothing preventing an injurer and insurer from entering into a contract where the injurer pays the insurer a premium, and in exchange the insurer will pay the cost of an accident up to some contractually fixed cap; this is a common practice in insurance markets. If it is profitable to do so, then private parties will already use capped liability as a means of avoiding the uninsurability problem. Similarly, if insurers were unwilling to offer uncapped liability contracts but were willing to offer capped liability contracts, there is nothing preventing them from forming such contracts under the status quo. Because of this, legislated capped liability will not expand the availability of insurance that parties can voluntarily purchase. Instead, the impact of capping injurer liability would be to shift residual risk (for damages over and above the cap) from injurers to victims – and so would transfer wealth from victims to injurers. This risk transfer could also have an undesirable effect on project selection, by making injurers more willing to run socially undesirable projects (because they no longer bear risk above the cap), and so could reduce welfare.

In order for a case to be made for capped liability to increase insurance availability, there must be a compulsory insurance system, where parties are forced to purchase insurance that they would not purchase voluntarily. If uncapped liability insurance is compulsory, but such

insurance is not available because of uninsurability problems, then there may be socially desirable GMO projects that injurers will not undertake, and so a case could be made for capping liability on compulsory insurance.

4.9.3 Performance bonds

A system of "performance bonds" has been suggested as another mechanism to try and mitigate the problem of insufficient precaution from judgement-proof injurers. The effect of such a system depends on how it is implemented. The current system of performance bonds used in resource management in New Zealand is actually a form of compulsory insurance, and the same issues apply. In this system, firms required to pay a performance bond pay premiums to an underwriter, who guarantees to pay a stipulated amount (not necessarily equal to losses) in the event of a pre-defined accident. This method relies on the availability of insurance contracts and has the same uninsurability problems as compulsory insurance, and acts as a ban on activities requiring a bond if insurance is unavailable. Such a system will also contain moral hazard problems if the insurer cannot monitor and contract on precautionary behaviour.

Another way of implementing performance bonds is to require a GMO applicant to actually post an amount of money determined by ERMA. If this system is used, then the bond must eventually be returned to the applicant, or interest must be paid to the injurer on the bond. If neither of these options are used, then the bond has no effect on firms' incentives for precautions, as they receive the same payoff (zero) from the bond regardless of whether or not an accident occurs.

If the bond is to be returned, this must occur after a pre-determined period. It is not feasible to return the bond "after the risk of damages is removed", because damages from a GMO release may not manifest for an indefinite period, so some semi-arbitrary period which captures most of the risk would need to be chosen.[14] To prevent investment distortions, the bond would need to be returned with a fair rate of return (which will be difficult to determine). Alternatively, a return on the bond could be paid to the injurer each year until an accident occurs. If this return was set appropriately (ie to offer a fair real return), then the bond requirement would not distort investment.

Requiring a performance bond paid in cash does not necessarily bar injurers from spreading this risk elsewhere. They may be able to borrow the up-front payment from capital markets using the future return of the bond as security, and make payments on this borrowing that would effectively act as an insurance premium. This would have the same effect as paying premiums to an underwriter, the only difference being that the underwriter would pay money only if an accident occurs, whereas the lender would forgo the bond repayment should an accident occur. These are equivalent, since a payment and a forgone gain are really the same thing. In other words, a scheme requiring a cash payment from applicants where the bond is later returned could have the same effect as a scheme requiring an underwriter. Effectively a bond would become a capital market instrument, and could be traded.

If there is significant heterogeneity in the risks across projects, it may that some projects need a performance bond (or compulsory insurance requirement), but other low risk projects may

[14] One method would be to return the bond with interest once the intellectual property right (IPR) expires. This would make some sense since once the IPR expires, the applicant is no longer able to prevent other firms from independently releasing the same GMO, and so it would be very difficult to prove that any damage was caused by the applicant. If a semi-arbitrary date must be chosen, IPR expiration seems as good as any other.

not. It may be more efficient to allow ERMA to determine which projects need a bond (and how much these bonds need to be [15]) on a case-by-case basis, rather than having a blanket rule. ERMA is likely to have better information than any other potential body (since they are specialised in GMO risk assessment) and can be more flexible than a legislatively dictated bond requirement, and may make smaller judgement errors. While a case-by-case management system would have higher administrative costs than a blanket rule because each project would require a risk-assessment, ERMA is already required to make a risk-assessment when considering whether to approve a GMO release, and so many of the administrative costs will be incurred regardless.

Though these problems are significant, they are not insurmountable. A well-designed performance bond scheme would: include regulatory flexibility based on the characteristics of application, allow a cash payment rather than under-writing when insurance is not available, and return the bond with interest after some clearly fixed period of time or pay a fair annual return. If these are not met, then the bond could add extra costs to GMO projects, and so deter investment in GMOs.

The effect of such a performance bond scheme would be to increase incentives for precaution and guarantee the existence of some money for cleanup or compensation. Though similar to a compulsory insurance scheme, the information requirements for an efficient performance bond scheme are higher than those for compulsory insurance, because a performance bond tries to mimic compulsory insurance without using market mechanisms to assess risk and set discount rates and prices, and so compulsory insurance may be better than performance bonds. However, if there are major uninsurability problems, a performance bond system could be better than compulsory insurance, because it may have a smaller impact on deterring investment.

4.9.4 Catastrophe bonds

If the problem behind uninsurability is the size of payments rather than ambiguity, then alternative financial mechanisms could mitigate the problem. Some Commission submitters propose the use of a "catastrophe bond", a financial instrument designed to help spread the risk for accidents that inflict very high damage. Under a catastrophe bond, a party facing some very large potential liability (such as an earthquake) issues a bond that pays its face value at the maturity date unless a specifically defined accident occurs (such as an earthquake of at least a particular Richter scale rating in a particular area). Financial markets thus value the bond based on their expectations about the probability of the accident occurring.

The advantage of catastrophe bonds is that they draw from capital markets, which are deeper and have more capital available than insurers and reinsurance markets, and are more able to deal with very large losses.

However, catastrophe bonds face several problems. First, there can be difficulties in contractually specifying the window in which the bond does not pay off. This could be difficult to define for a GMO accident. Second, there may be a moral hazard problem, and this could be worse than for insurance, since bond-owners would be less able to monitor

[15] Inherent in any performance bond system is the difficulty in selecting the appropriate level of the bond. If the bond is set too high, then this will deter desirable investment, and if the bond is set too low, then the injurer may still take insufficient precaution because of limited liability.

precautions than insurers. Catastrophe bonds are best suited to circumstances such as natural disasters, where there is no ability to take precautions against the accident occurring[16].

Third, there has been little investor interest in catastrophe bonds thus far. Bantwal & Kunreuther (2000) propose several reasons for this. First, investors are unfamiliar with a new type of asset. Second, investment managers face strong personal incentives to avoid big losses (which catastrophe bonds would yield should an accident occur), particularly on new and unfamiliar asset types. Finally, investors may be ambiguity averse, in the same manner as insurers. Investors are unwilling in invest in assets where they do not have a good idea of the probability distribution of payoffs, and so do not know how to price the asset. Investors may also have less information about the probability distribution of accidents than insurers, who might be in a better position to acquire specialist expertise in GMO risk assessment. This is a major problem for using catastrophe bonds for GMOs.

Thus, catastrophe bonds may be able to mitigate the problem of large losses from accidents, but not the potentially more important problem of ambiguity aversion. The moral hazard problem they create may also be serious, if there are precautions that can be taken to reduce the probability of high-damage accidents.

4.9.5 Public compensation scheme

Another option available is a socialisation of the risk of GMO release by creating a public compensation system, similar to ACC, whereby government compensates victims of GMO accidents. Such a scheme may be attractive if there are few foreseeable precautions that can be taken, if legal costs are very high relative to the level of harm involved, or in conjunction with a negligence liability system that does not compensate victims. This could either be funded from general taxation, or through an industry fund, such as that discussed below. The main advantage of a socialised scheme is to achieve equity/compensation goals with lower administration costs than those of a liability system. However, such a scheme will not provide incentives for precaution, and so another instrument is needed to provide these incentives (such as negligence liability).

4.9.6 Industry fund

Another suggestion has been the formation of a fund to which industry members contribute as a dedicated compensation fund. Industry members would make some annual contribution to the fund, which may change over time depending on the number of accidents that occur. The effects of the fund would depend on what the fund was used for: accident cleanup, victim compensation, or paying legal fees for victims to sue injurers.

Such a fund would have some initial setup problems. Industry members would need to be clearly defined, an aggregate funding level would need to be determined, a mechanism for determining how this should change given the number of accidents and entry and exit of firms, and a fair and efficient system of dividing the burden of this funding between contributors. However, these problems are not insoluble.

[16] These problems occur only for precautions that change the probability of the accident, since the benefits of such precautions go to bondholders, not to the parties liable for accident costs. In contrast, there is no moral hazard problem for precautions that merely reduce the cost of the accident when it occurs, such as strengthening buildings, since the benefits of these precautions go to the parties liable for accident costs, not the purchasers or the bond.

The more serious problem with such a fund is that it provides very little incentive for individual firms to take precaution. There is a free-rider problem where the costs of investing in precaution are borne by each individual firm, but the costs of an accident is borne by the fund and so the industry as a whole. The only solution to this is to ensure that individual firms are still held liable for their own damages, even if the fund is initially used as a source of compensation. Efficiency could also be improved by experience-rating contributions of industry members, so firms that have had accidents pay larger contributions in future. This will have little impact if there are few accidents, or if accidents that occur are large enough to bankrupt the firm liable for them. Similarly, contributions could be based on estimates of the risks of particular projects.

If the fund provides compensation to victims, then there will be less incentive for injured parties to take legal action, and so fewer lawsuits and less incentive for precaution. If this compensation is equal to the level of damage suffered, then victims will also face little incentive to take their own precautions.

If the fund is used to pay the legal costs of alleged victims, then it could make injurers more fearful of liability and so prevent insufficient precaution, but could also lead to frivolous and unnecessary lawsuits, as opponents of GMOs take unjustified lawsuits in the hope of winning a case or settlement from a GM firm, or of raising GM costs.

A compensation fund should only be set up in place of liability if it is believed that there are few effective precautions that can be taken by either injurers or victims, or if victim compensation is a high priority and alternatives such as liability are ineffective (such as if the problem of identifying who caused an accident is insurmountable).

The commonly cited example of such a fund is the USA's Superfund, funded both by industry contributions and federal taxes. The main goal of Superfund was to provide liquid assets to be used to fund cleanup operations of chemical spills and toxic waste sites, since lawsuits and appeals may take years to provide funds to victims. Such a goal may not be readily applicable to GMOs – it is unclear how much "cleanup" would be possible from a GMO accident. It may also be inefficient in some cases for cleanup if the costs of cleanup are more than the reduction of damage from cleanup – and given that the benefits of the cleanup will not be borne by the party making the decision over whether to fund the cleanup, there will be imperfect incentives for this decision. Superfund was also designed to work in conjunction with a tort litigation system, where lawsuits against individual would still be pursued.

Superfund has been heavily criticised as having very high transaction and legal costs. The Commission notes there have been claims that Superfund has resulted in "lengthy and expensive litigation, delays and inefficiency in clean ups, waste and even fraud; there are claims that 36 to 60 cents of every dollar put into Superfund has gone in legal and other transaction costs." (Eichelbaum 2001, p324 para 65).

4.10 Other issues

There are some other issues that should also be considered when designing a liability regime for GMOs, that are unique to GMOs in New Zealand.

4.10.1 Case-by-case analysis

Some parties have suggested that ERMA should have the ability to make decisions on a case-by-case basis rather than have general legislative or regulatory rules. While it is unlikely to be feasible to micromanage precautions through command-and-control decisions by a regulator (particularly if firms have better information about their proposals than ERMA), there are likely to be gains from providing flexibility for ERMA to set some specific release conditions or requirements for performance bonds and compulsory insurance.

Given that requiring compulsory insurance has costs and benefits and that these will vary between project proposals, a blanket rule describing activities where these instruments are required will likely mean that there are projects where the benefits from requiring these instruments outweigh the costs but they are not required under the rule, or projects where the costs outweigh the benefits but are required by the blanket rule. Allowing case-by-case management may reduce this problem, and would allow ERMA to only require bonds in cases where there is a high risk of default. If firms know that they will be required to pay performance bonds if they try and avoid liability by operating GMO activities through low-asset subsidiaries, then this may reduce incentives to operate through such subsidiaries.

The trade-off of case-by-case management of requirements for compulsory insurance or performance bonds is that this will have higher administration costs than a blanket rule.

4.10.2 International issues

At their core, most of the above arguments on determining the optimal liability regime assume that equal weight is placed on injurer and victim benefits in the cost/benefit analysis, regardless of whether they have foreign or New Zealand owners. An argument could be made that such analysis should place a smaller weight on (or ignore) profits to foreign firms because these profits do not directly benefit New Zealanders, while most risks and costs of GMOs will fall on New Zealanders. However, there are several problems with treating foreign profits/costs as less important than domestic profits/costs. First, this could create undesirable investment and price distortions. It could limit the ability of domestic biotechnology firms to secure foreign investment to expand their operations, and could increase prices to New Zealand consumers. Second, such a move could be seen as a non-tariff trade barrier. This could cause other countries to reciprocate with other trade barriers or to take action against New Zealand through the WTO, and could also weaken New Zealand's attempts to get other countries to lower their trade barriers to New Zealand exports and jeopardise the possibility of free trade deals. Finally, it may be impractical for regulators to undertake such analyses. Consider for example if a domestic firm applies for and receives consent to release a GMO – would a regulatory system that treated foreign firms differently from domestic ones then prevent the domestic firm from merging with or being purchased by a foreign firm, or from trading its intellectual property right on the GMO to a foreign firm?

Another concern raised by some people is that New Zealand could be used as a "testing ground" for risky GMOs by multinational firms. Such firms could have incentives to undertake risky GMO projects in New Zealand that are not profitable (or socially desirable for New Zealand) as standalone projects, in order to gain more information for future release elsewhere. New Zealand would be a desirable place to undertake such projects because its geographic isolation means that accidents could be contained, and so accident costs would be lower than release elsewhere. If this concern is valid, then this supports use of strict liability and performance bond requirements for such projects, as these provide stronger incentives for firms to refrain from undertaking overly risky projects.

4.10.3 What about the future?

A final issue is that the design of a liability regime must not only be appropriate in present circumstances, but should be flexible enough to handle future changes with minimal cost. While there is little information now about many aspects of GMOs, this is likely to change over coming years as more research is undertaken. It may be that more information about risks is discovered and this reduction in ambiguity means that insurance agents become more willing to provide liability insurance. It may be that there are changes in the costs or benefits of use of GMOs because of changes in consumer demand in favour of organic or GM foods. It may be that there is new information about the types and effectiveness of precautions. These changes may mean that a different liability regime would become optimal. This suggests that some discretion should be left to regulatory authorities and courts rather than stipulated in legislation, as it is easier for regulators to change policy or courts to discover or set new law than to go through the long process of legislative reform.

5.0 Conclusion

This paper has presented an outline of the issues that will determine the best liability regime for GMOs. While possibly offering large benefits, genetically modified organisms may cause accidents that inflict costs on third parties, through personal injury, economic loss or environmental damage. If GMOs do not cause such accidents, then the choice of liability system is unimportant. However, if GMOs can cause accidents, then in the absence of any liability system, injurers will take insufficient precaution to reduce the risk of such accidents. Different liability systems could lead to different outcomes, so the optimal liability system will be the one that leads to the best institutional structure should GMOs turn out to cause accidents. So, what is the best liability system?

While there are many other hazardous activities, there is considerable controversy over what lessons can be drawn from the experiences of liability for these activities, and over the degree of similarity between GMOs and such activities. This motivates a separate examination for the optimal liability regime for GMOs.

A range of issues that must be considered when designing a liability regime. The question of negligence vs. strict liability is central to the design of a liability regime, and the answer to this question lies in providing incentives for firms to take efficient precaution and activity levels. While liability systems may be able to provide incentives for parties to take efficient precaution, they are not able to also provide incentives for firms to only undertake socially desirable projects. Even with the presence of a regulator, there are a range of factors (such as asymmetric information, the sunk nature of research costs, and regulator bias) that suggest that strict liability will generally perform better than negligence.

The two main problems with strict liability are if GMO projects have large positive externalities (in which case strict liability could deter desirable GMO activity), or if there is the potential for large accidents to occur that deal more damage than the assets of the liable firm (in which case firms will have insufficient incentive for precaution). There are a range of instruments which might help mitigate this problem (such as compulsory insurance, performance bonds or catastrophe bonds), but each has weaknesses which would make any solution imperfect.

While this analysis has focused on issues raised in the New Zealand liability debate, many of the issues raised are broadly applicable to GMO management in other countries or to other potentially hazardous activities.

References

Bantwal, Vivek and Kunreuther, Howard (2000) "A Cat Bond Premium Puzzle?", *Journal of Psychology and Financial Markets* 1:76-91

Barr, N.A. (1993) The economics of the welfare state, Widenfeld and Nicolsen, London

Brown, Omer F. (1999) "Nuclear liability: a continuing impediment to Nuclear Commerce", *The Uranium Institute 24th Annual Symposium*, London

Charles River Associates (2001) "Review of Chen, Palmer & Partners and Simon Terry Associates, *Who Bears the Risk?*", report for Buddle Findlay commissioned by Ministry of Research, Science and Technology, Wellington

Chen, Palmer & Partners and Simon Terry Associates (2001) Who bears the risk? : Genetic modification and liability, Chen, Palmer & Partners and Simon Terry Associates, Wellington

Christensen, Mark and Horgan, Paul "Genetic Modification: The Liability Debate", *Anderson Lloyd Caldwell*, 2002

Cohen, Daniel (2001) *Royal Commission on Genetic Modification: Witness Brief*, Submission IP0005, HortResearch

Eichelbaum, Thomas, Chairman (2001) *Report of the Royal Commission on Genetic Modification*, New Zealand Royal Commission on Genetic Modification, Wellington

Environmental Risk Management Authority New Zealand (1998) Annotated Methodology for the consideration of applications for hazardous substances and new organisms under the HSNO Act 1996, Wellington

Environmental Risk Management Authority New Zealand (2000) Taking account of cultural, ethical and community issues, *Guidelines in relation to work on genetically modified organisms carried out under the HSNO Act 1996*, Wellington

Hutton, Stephen R. (2004) The Economics of Liability for Genetically Modified Organisms, New Zealand Institute for the Study of Competition and Regulation, Victoria University of Wellington, Wellington.

Kunreuther, H. Hogarth, R. and Mezaros, (1993) J. "Insurer ambiguity and market failure", *Journal of Risk and Uncertainty*, December 1993

Law Commission (2002) "Liability for Loss Resulting from the Development, Supply, or Use of Genetically Modified Organisms", Law Commission Study Paper 14

Nahkies, Graeme Loutit, Margaret & Rogne, Sissel (2003) A Review of the Capability of the Environmental Risk Management Authority (ERMA) relating to the Risk Management of New Organisms, Report commissioned by the Minister of the Environment, Wellington

Shavell, Steven (1982) “On liability and insurance”, *Bell Journal of Economics* 13(1):120-132

Todd, Steven (2001) “Liability issues involved, or likely to be involved now or in the future, in relation to the use, in New Zealand, of genetically modified organisms and products”, Documents requested in response to Commission Questions, New Zealand Royal Commission on Genetic Modification.

Viscusi, W. Kip (1996) “Alternative Institutional Responses to Asbestos”, *Journal of Risk and Uncertainty*, 12:147-170