David vs Goliath: the bifurcation of public policy concerning organic agriculture and biotechnology in Queensland.

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The Australian organic industry has undergone recent and rapid expansion in response to growing consumer concern over food safety issues. The industry is growing at 20-30% per annum and has an annual gross value of $200 million. The Australian organic industry is vehemently opposed to the genetic engineering of foods and has requested that the Australian Government impose a five-year freeze on the import, sale and production of genetically engineered foods. In contrast, the Queensland Government is seeking to accelerate and nurture competitive bioindustries through the provision of its $270 million Bioindustries Strategy. This paper will examine the recent growth of the Australian organic industry, the potential conflicts between biotechnology and organic industry development and conflicting government policies guiding the expansion of the organic and biotechnology industries.

Keywords: organic agriculture, biotechnology, and precautionary principle

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1.0 Introduction:

The agriculture sector in Australia has undergone significant and rapid change in the last 40 years. Farmers have had to contend with declining profitability, environmentally conscious consumers and increasing competition. New trends are emerging in food production systems in response to demand (consumer) and production (supply) pressures, and societies' desire to control and reduce some of the externalities resulting from agriculture.

There are many public good aspects associated with the production of food and fibre crops in Australia. The spillover impacts and non-rivalness characteristics of these public goods include consumer food safety, environmental impacts, perceived risks of genetically modified (GM) crops, chemical contamination and animal welfare concerns. Of particular interest in this paper are the externalities associated with biotechnology and organic farming in agriculture.

When consumers make decisions to purchase foods they consider a range of food safety, environmental and process factors along with the primary use attributes of the good itself (Caswell 1998). In some cases consumer demands operate through the market to reduce unwanted side-effects (eg the supply of dolphin-safe tuna). In other cases though, the Government has a role to provide public goods, limit externalities or provide a framework in which rights can be specified and enforced. For example, Australia now has strict labelling laws for foods with GM components, and trials of GM crops are carried out under licence. Consumer concerns about food quality and safety are leading to increased quality assurance by food companies and increased regulation by governments (Caswell 1998).

Another outcome of consumer concerns over food safety, health and unethical farming practices, and consumer demand for chemical and GM free foods appears to be the growth in demand for organic produce and the expansion of the Australian organic industry. At the same time, there are an increasing number of farmers growing GM crops because of the production increases and cost savings available. However, there is potential for GM crops to create some externalities on organic farmers, which raises the question of how far these two themes in agriculture can continue to develop.

Kinnear (2000a) claims the single largest threat to the future of Australia's organic industry is agricultural biotechnology. The term biotechnology covers a wide range of technologies that use living organisms, biochemistries or synthetic DNA to make or modify products, improve plants or animals, or develop micro-organisms for specific uses (Queensland Bioindustries Office 2000). It is most commonly associated with the use of genetically modified organisms (GMOs) where foreign genes are inserted into living organisms.

The introduction of biotechnology to agriculture heralds a revolution in food production systems. Gene technologies have the potential to contribute to improved human health, create safer and more secure food supplies, contribute to wealth creation in rural areas and ensure a more sustainable environment. The presence of

GM crops also provides a number of environmental and human health risks, and poses a threat to organic produce through the unintended contamination of genetically modified materials.

There are tradeoffs involved in the development of both biotechnology and organic crops in Australia. Given the substantial consumer concerns over GMOs and other food safety issues, and the current levels of government regulation and investment of public funds, the debate over where those tradeoffs should be set is likely to intensify. There is already growing interest from economists in these questions (eg Caswell 1998, Feldmann et al 2000).

The development of food biotechnology industries has to date involved scientists and regulators much more than economists. More recently though, there has been growing recognition that to address food safety issues and other uncertainties, expertise from other disciplines needs to be considered (Appell 2001).

Recent food scares in the UK and Europe has made consumers increasingly concerned about the quality and safety of their foods. Aside from the E-coli and salmonella food scares that occurred in recent years, the bovine spongiform encephalopathy (BSE) out break is the most well known problem in the European food industry. The recent Phillips report into BSE in the United Kingdom found that scientists had to take some blame for the delays and mistakes made, and that the public had been shielded from much of the debate about uncertainty and risk (Coglan 2000).

At the same time there has been increasing concerns raised over the risks associated with GMOs in food (Feldmann et al 2000). The extent of those concerns has justified mandatory labelling in many countries. Governments have provided a public good by insisting that foods be labelled correctly, and helped to maintain confidence in the markets for food products. What is more difficult to ascertain is the point at which the benefits of mandatory labelling begin to surpass the (often substantial) costs of providing that labelling and the associated verification processes (McCluskey 2000).

The potential costs associated with GMOs are not just related to food safety, but also to the possibility of environmental impacts (eg breeding mutant weeds), and spillover effects on other farming enterprises through such effects as pollen drift. The current regulation of how GM crops are grown in Australia are designed to minimise such risks. However, the spillover effects on organic growers are largely ignored.

The following three sections of this paper will report on the expansion of the Australian organic and GM food industries, and the spillover effects that GM crops may impose on the organic industry. In the fifth section of the paper, discussion will be presented about how economics may be used to address these issues. Some conclusions and directions for further research are drawn in the final section.

2.0 Organic Agriculture in Australia

The organics industry in Australia is a relatively new industry that first emerged through the work of Alex Podolinsky who formalised Biodynamics at least 50 years ago. The first affiliated organics associations in Australia emerged in 1986 with the establishment of the Organic Retailers and Growers Association of Victoria and the National Association of Sustainable Agriculture of Australia (Kinnear 2000a).

Australia has in excess of 7.65 million hectares of land certified organic. This is considerably more than the US and Europe that has 1.3 million and 3 million hectares certified organic respectively. Australia has approximately 1,670 certified growers and/or processors (Kinnear 2000a).

A national standard defining “organic” was adopted in Australia for export produce in February 1992. The national standard describes minimum production requirements for food and fibre to be labelled as organic. The standard is overseen by the Australian Quarantine Inspection Service (AQIS) and was developed by the Organic Produce Advisory Committee (OPAC).

In Australia “Certified Organic” produce is grown using appropriate land management practices without the use of artificial fertilisers, herbicides, pesticides, growth regulators, antibiotics, hormone stimulants or under intensive livestock systems.

Internationally, growth in the organic food industry has been rapid. Worldwide the organics industry is valued at approximately $US20 billion and annual growth is continuing at 20-50% per annum. Kinnear (2000a) predicts that if current growth rates continue for the next ten years, then 30% of food consumed in Europe by 2010 will be organic. McCoy and Parlevliet (1998) report that organic foods are the fastest growing sector of the food industry in the USA, Japan and a number of EU nations. The Food and Agriculture Organisation (2000) suggest that organic agriculture is one of the fastest growing sectors in agricultural production.

The major markets for organic products are Japan, Germany, France, the UK and the Netherlands and the USA. Other European nations with high per capita consumption of organic foods include Denmark, Austria, Sweden and Switzerland (McCoy and Parlevliet, 1998; Team Canadian Market Research Centre and the Canadian Trade Commissioner Service, 1999; KPMG 1999; Green, 2000).

The Australian organic industry has undergone recent and rapid expansion. In 1990 the industry was worth $28 million (Lyons and Lawrence 2000). In 1998 Carson (1998) estimated Australia's organic food sales to be 2% of domestic food sales, having an annual retail value of $90 to $100 million with potential export sales of $30 million. In 2000 the Australian organic industry had an annual gross value of $200 million, with $40 million of product exported (Kinnear 2000b). Kinnear (2000b) estimates the industry is growing at 20-30% per annum dependent on location and the individual business. Government funding to support this industry has increased in recent years, however the actual amount spent on organic systems is only a fraction (0.1%) of the billion dollars invested in rural research in Australia per annum (Griggs 2000). In 2000 the organic industry received less than $1 million for R,D&E from the Federal and State Government. Not surprisingly the Organic Federation of Australia rate the lack of funding for R,D&E within the organics sector as one of the industries largest impediments to growth (Kinnear 2000a).

2.1 Environmental Aspects of Organic Farming

The guiding principles for organic agriculture are outlined in the Australian standard for organic agriculture. The standard states that organic crops are:

> *"produced in soils of enhanced biological activity, determined by the humus level, crumb structure and feeder root development, such that plants are fed through the soil ecosystem and not primarily through soluble fertilisers added to the soil. Plants grown in such systems take up essential soluble salts that are released slowly from humus colloids at a rate governed by warmth. In this system, the metabolism of the plant and its ability to assimilate nutrients is not over stretched by excessive uptake of soluble salts in the soil water (such as nitrates). Organic farming systems rely to the maximum extent feasible upon crop rotations, crop residues, animal manures, legumes, green manures, mechanical cultivation, approved mineral-bearing rocks and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests" (KPMG 1999).*

A review of the literature regarding the sustainability of organic farming presents conflicting results. This may not be surprising given the apparent lack of R,D&E invested within the industry. The international federation of organic agricultural movements suggests that organic agriculture is sustainability put in practice, built on holistic concepts that seek to achieve sustainable systems that incorporate land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable (IFOAM 2000).

In January 1999 the FAO Committee on Agriculture (COAG) concluded that many aspects of organic farming were important elements of a systems approach to sustainable food production and recognised the environmental and potential health benefits of organic agriculture and its contribution of innovative technologies to other agricultural systems and to the overall goals of sustainability. Recognising these benefits COAG has proposed to give the practice associated with organic agriculture a place within its sustainable agricultural programs (IFOAM, 2000).

Contrary to this view, Avery (1995) in Lyons and Lawrence argues that organics is incapable of sustaining soil fertility, increases soil erosion (through the use of tillage instead of chemical control of weeds), cannot result in any 'natural' balance between production and pests, and has no ability whatsoever of providing a foundation for feeding the world's burgeoning population. Lyons and Lawrence (2000) suggest that similar sentiments have underpinned scientific agriculture in Australia and New Zealand. Forrer et al. (2000) challenges claims that organic production methods are better for the environment, citing the use of copper-based fungicides and other allowable chemicals as clearly unhealthy and damaging to the environment.

Some of the difference in views arises because organic farming is often associated with a number of alternative agriculture themes, including groups that are opposed to corporate agriculture, globalised markets, and some of the R,D&E establishment.

Many people advocating organic farming take a very different approach to collecting and testing new knowledge to that used by the scientific world (Morgan and Murdoch 2000). While organic farmers will often focus on a holistic approach to farming systems, scientific methods of testing for cause and effect usually focus down to the bare minimum of controllable factors.

This provides one explanation for why organic farming is often viewed by its proponents (and detractors) as being so different from more conventional agriculture. The lack of a scientific basis for many organic farming practices, and the untested claims for sustainability led Tweeten (2000), in a guest editorial to CHOICES, to characterise the organics industry in the United States as a $6 billion mis-allocation of resources.

While a definitive answer regarding the sustainability of organic farming remains unclear in the literature, its advocates (eg Kinnear 2000d) conclude that organic farming systems have the most to offer societies search for sustainability. They view it as a holistic agricultural system that is clearly focused on sustainability and practices that do not harm social systems or societies' natural resources base.

3.0 Biotechnology in Australian Agriculture

Biotechnology is the use of biological processes. It includes "gene technology" which enables characteristics to be moved between unrelated organisms by transferring individual genes. The first generation of crops derived from agricultural biotechnology is now reaching commercial application in Australia. This generation of GMO's has been focused on introducing insect, disease and herbicide resistance to high value, broadacre field crops (Thomas et al. 2000).

During 1996 -1997 25,000 crop field trials were conducted globally on more than 60 crops with 10 traits in 45 countries (James 1997). The global arable land area devoted to transgenic crops increased 4.5 fold from 2.8 million hectares in 1996 to 12.8 million hectares in 1997, approximately 30 million hectares in 1998 and 40.5 million hectares in 1999. The United States (US) accounted for about 64% of the global acreage, followed by China and Argentina (Altieri, 2000; National Farmers Union, 2000). As Feldmann et al (2000) point out, genetic engineering is too important, and too widespread, to ignore.

One of the first GMO's to be commercially released in Australia was bacteria protective against crown gall infection (No Gall) released in 1991. Since then two genetically modified carnations (Florigene blue carnations and Florigene carnations modified for longer vase-life) and insect and herbicide resistant cotton have been commercially released (Thomas et al. 2000). Numerous other GM crops are being grown in trial plots in Australia in addition to those commercially available.

Other GM crops in Australia that have reached the commercial stage but have as yet not been released for commercial use include Bresatec transgenic pigs which have been genetically manipulated to produce lean pork, Salmonella vaccine for use in poultry and two genetically modified enzymes developed for use in manufacturing processes (ARMCANZ 1997). Globally 40.5 million hectares of land was planted to transgenic crops in 1999. The United States (US) accounted for 64%, followed by

China and Argentina (Altieri, 2000; National Farmers Union, 2000). Currently in Australia only genetically modified cotton and carnations are approved for commercial cultivation (Thomas et al. 2000). In the 2000/2001 growing season Australia will grow 165,000 hectares of Ingard cotton and 10,000 hectares of Roundup Ready cotton (Holmes, J. pers comm. 8 January 2001). GM foods currently available in the marketplace in Australia include foods derived from soybeans, canola, corn, potato, sugar beet and cotton. The majority of these foods are derived from GM crops grown overseas (ANZFA 2000).

The current focus of agricultural biotechnology is the development of herbicide, pest and disease resistant crops. Herbicide resistant crops (HRC's) and insect resistant crops accounted for 54 and 31% of transgenic crops in 1997. Increasingly large areas of transgenic soybean (18 million hectares), maize (10 million hectares), potato, tomato, tobacco, and cotton are commercially deployed in agricultural landscapes worldwide (Altieri 2000).

The main proponents of these new crops are the multinational companies responsible for their development (Monsanto, DuPoint, Norvartis, etc) and the farmers that benefit from their productivity enhancing qualities. These groups claim the carefully planned introduction of transgenic crops will reduce and in some instances eliminate the enormous crop losses due to weeds, insect pests and pathogens, and that the use of these crops will benefit the environment by significantly reducing the use of agrochemicals. In Australia the agricultural sector currently expends $1.2 billion on agrochemicals per annum (Nordblom and Medd, 2000).

The potential risks associated with GMOs can be summarised into two main categories. The first is where GMOs may have some potential impact on human and animal health, while the second (and perhaps most controversial) is where GMOs may have some environmental impacts. These potential risks are discussed in the following sections.

3.1 Human Health Concerns Associated with GMO's

Currently in Australia many food ingredients from GM soybean, canola, corn, potato, sugar beat and cotton oil have been approved for food use (Dean 2000). There is no evidence that genetically modified foods are causing health problems in humans (Feldmann et al 2000). However, there are lingering fears in the public arena that as yet unspecified effects may cause health problems in humans.

Some commentators have raised possibilities that GM foods may pose a health risk to consumers through potential allergenicity and carcinogenicity, alterations in nutritional qualities of foods, and the development and accidental release of antibiotic resistant microbes and toxins (Uzogara 2000). There have also been concerns that animals fed on GM grain could develop a buildup of antibiotic resistance. However, little scientific evidence has been found for any of these risks. Different gene transfer techniques and quality assurance proceedures have been introduced to minimise those risks further (Feldmann et al 2000).

Public concerns over GM foods vary considerably from country to country. In the United States, there is little public concern while there has been widespread protests in Europe. Feldmann et al (2000) suggest that there are two main reasons for this difference. The first is that there are mandatory labelling requirements for GM foods in Europe, but none in the United States. Consumers in the US may not be nearly as aware of GM components in foods. The second is that there is much less trust in Europe in food safety regulation systems, probably because of the incidents where food safety problems were not initially detected, and then the likely consequences were downplayed (Feldmann et al 2000).

Proponents of GM foods have claimed that increasing public awareness and understanding of GMO's will increase the acceptance of GM foods within society. Research by Almas and Nygard (1993); Wagner, and Torgerson et al. (1997) in Norton et al. (2000), has found this is not the case. Indeed Cambell and Wheeler (2000) in a national survey of public attitudes towards biotechnology in Australia found that consumers perceive GM foods as an extension of the problems which have resulted from pesticides. The survey found that while many people accepted genetic manipulation of food as a fact, they were distrustful of both government and industry initiatives in this area and would stop the use of the technology if they thought it possible.

Feldman et al (2000) and the Philips inquiry into BSE (Coglan 2000) have concluded that public distrust has arisen because authorities and proponents have tried to downplay or ignore the risks. Their recommendation is to find more open processes for transferring information about risk and scientific uncertainty. The process for dealing with uncertainties regarding human health is one of the challenges of the coming decades.

3.2 The Ecological Risks of Genetically Modified Crops on Agroecosystems

Given the power of biotechnology to produce combinations of genes not found in nature, Krimsby & Wruberl (1996) and Rissler & Mellon (1996) in Altieri (2000) list some of the most serious ecological risks posed by the commercial-scale use of transgenic crops as:

- Reduced crop genetic diversity by simplifying cropping systems and promoting genetic erosion;
- Potential transfer of genes from HRC’s to wild or semi-domesticated relatives, thus creating super weeds;
- HRC volunteers becoming weeds in subsequent crops;
- Reduced agro-biodiversity in time and space;
- Vector mediated horizontal gene transfer and recombination to create new pathogenic bacteria;
- Vector recombination to generate new virulent strains of virus, especially in transgenic plants engineered or viral resistance with viral genes;
- Development of insect resistance to Bt toxin;
- The untargeted elimination of beneficial insects and soil biota from the massive use of Bt toxin in GMO crops.

3.3 Environmental Problems of Herbicide Resistant Crops

The intention of HRC's is to not destroy ecological processes, rather HRC's aim to simplify weed management for farmers by reducing herbicide use to post emergence situations using a single, broad-spectrum herbicide that breaks down quickly in the soil. Altieri (2000) suggests that in reality the use of HRC's is likely to increase the use of specific herbicides, and given herbicide volumes and acreage coverage production costs are likely to increase. Proponents of HRC's suggest they offer industry enhanced yield dependability, soil, and water conservation and are compatible with minimum tillage systems, all highly desirable agronomic goals.

Ecologists have a grimmer outlook on HRC's and predict in Altieri (2000) a number of serious environmental problems associated with their wide spread use. These include:

- Development of herbicide resistance;
- Ecological impacts;
- Creation of "Super Weeds"; and
- The reduction of agro-ecosystem complexity.

3.3.1 Herbicide Resistance

It is well documented that when a single herbicide is used repeatedly on a crop the chances of herbicide resistance developing in weed populations greatly increase (Holt et al 1993). Altieri (2000) suggests that as the acreage of broad-spectrum herbicides increases the resistance problem will be exacerbated. Although glyphosate is considered less prone to weed resistance, its increased use in Australia has resulted in documented resistance of annual ryegrass, quackgrass, birdsfoot trefoil and *Cirsium arvense*.

3.3.2 Ecological Impacts of Herbicides

Whilst it is widely accepted that bromoxynil and glyphosate (two commonly used herbicides) when properly applied offer little threat to ecosystem condition and human health, Goldbergs (1992)[1] work indicates that bromoxynil causes birth defects in laboratory animals, is toxic to fish and may cause cancer in humans. Bromoxynil is absorbed dermally whilst glyphosate accumulates in fruits and tubers. The presence of these herbicides in the environment may pose a much larger threat to ecosystem health and functions than is commonly believed.

3.4 Transgenic Crops as Weeds

Whilst there is the chance for some transgenic crops to become weeds in subsequent crops the real ecological risk lies in the transfer of transgenes from crops to other plants which may then become environmental weeds. Altieri (2000) argues that this hybridisation among distinct plant species is already occurring among wild, weed and crop plants. The cascading repercussions of these transfers may ultimately result in changes to plant communities and threaten centres of diversity.

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[1] Quoted in Altieri (2000)

A secondary result could be the transfer of genes from transgenic crops to organically grown crops. Crops able to outbreed, such as maize or canola are at greatest risk, although all farmers face gene contamination as not all countries enforce buffer zones and those that do use questionable distances. The contamination of a crop of Hyola oilseed rape (canola) in the UK last year with GM material (National Farmers Union 2000) has forced the EU to reassess safe minimum buffer distances between GMO and non-GMO crops.

A similar example is the US StarLink bio-corn disaster. StarLink corn seed is a GM variety developed by Aventis CropScience to repel pests. The technology was approved by US regulators for use only in stock feeds as it had the potential to cause allergic reactions in humans. In September 2000 the variety was discovered in the US food supply, triggering a recall of millions of taco shells, chips, cornmeal and other corn foods from the nations supermarkets (Edgar 2001).

3.5 Reduction of Agroecosystem Complexity

Altieri (2000) argues that the use of HRC's will enhance continuous cropping, remove the use of ecologically favourable rotations and polycultures susceptible to the herbicides used with HRC's. Such a cropping environment would provide ideal conditions for the unabated growth of weeds, insects, and diseases as many ecological niches are not being filled by other organisms.

3.6 Environmental Risks of Insect Resistant Crops

With the use of transgenic crops came the promise of reduced synthetic insecticide use with gene coding for Bt toxin. The gene responsible for the Bt toxin was first introduced into cotton in the US in 1996, and Australia in 1997. The success of Bt cotton in reducing insecticide use remains unclear with conflicting results from the US and Australia.

Altieri (2000) reports that an analysis of pesticide use in the 1997 growing season in 12 region/crop combinations showed no statically significant differences in pesticide use on Bt crops versus non Bt crops in seven sites in the US[2]. These findings are contrary to the Australian experience where Fitzgerald (2000) reports overall Bt cotton has needed an average of 50% less chemical insecticide than conventional varieties. This finding supports claims by seed companies that the direct costs and environmental externalities resulting from agricultural insecticides will be reduced by the use of GM cotton (Napier, 2000).

4.0 The Threat of GM Crops to Organic Agriculture

The rapid deployment of GM crops into the Australian farming landscape poses a number of serious threats to the Australian organic industry. These include:

- The threat of accidental contamination of organic produce with GM crops through hybridisation among distinct plant species;

[2] Falck-Zepeda et al (2000) estimated the net change in pesticide costs for growing Bt cotton in the United States. While it was positive or zero in four regions, it was negative in the other 23 regions.

- The unintended removal of beneficial insects from integrated pest management systems;
- The introduction of "terminator technology" and the patenting of genetic information and plant variety rights;
- Lost opportunities to capitalise on price premiums being paid for GE-free crops; and
- The loss of Bt pesticide sprays as a convenient means of controlling insects organically.

4.1 Genetic Contamination of Organic Crops

Australian and international food standards (ANZFA 2000b) prohibit the use of GM materials in food ingredients unless approved by the relevant regulating authority. Similarly in order to retain organic certification farmers are required to supply GM free produce. World standards for organic agriculture implemented by IFOAM prohibit GM material in organic product The genetic contamination of crops takes away the choice of organic farmers to grow GM free produce and their organic certification. Crops capable of outbreeding, such as maize and canola, are at greatest risk of accidental hybridisation and genetic exchange. Both of these crops are grown organically in Australia. Australia has no regulations governing enforceable minimum isolating distances between transgenic and organic fields. The OFA suggests that appropriate buffer zones should be enforced not only to limit genetic contamination, but to protect the rights of organic farmers to grow GM free produce. The OFA suggests a safe minimum buffer distance of 16 kilometres (Kinnear 2000d).

European genetic contamination of organic crops has already occurred. Kinnear (2000d) writes that $200,000 of organic chips were randomly tested by the EU and found to contain GM corn. Following two months of investigation the GM material was traced to pollen drift from a GM crop grown 6 miles from an organic corn farm in Texas. Research from the John Innes Centre in Norwich, states that pollen transfer in crops can be as far as nine miles with bees and many miles further with wind (Kinnear 2000d). The likelihood of similar accidents occurring in Australia is quite high if industry acceptable buffer zones are not implemented.

4.2 The Impact of GM Crops on Organic IPM Programs

The success of integrated pest management (IPM) programs in agricultural landscapes is highly reliant on maintaining healthy populations of predatory insects. Recent experience in the US has documented the unintentional mortality of monarch larvae fed on transgenic Bt corn pollen and confirmed that non-targeted and non-pest insects could be harmed through the consumption of GM plant material (Feldman et al. 2000). Altieri (2000) reports that Bt toxin moving through the arthropod food chain poses a serious threat to IPM programs in agroecosystems in Europe. Research in Switzerland shows that predatory insect larvae fed prey raised on Bt altered crops encountered 50% higher mortality rates than larvae fed on non-GM material.

Similarly Bt crops grown in large areas have the potential to starve predator insects of food as they require a small amount of prey to survive. Starving these insects of prey may reduce their numbers to small populations that are ineffective in controlling insect pests through a chemical free IPM program. Similar impacts would occur on natural populations of insect parasites that GM crops are designed to eliminate, especially egg and larvae parasites that are entirely dependent on live hosts for growth and survival.

The recent discovery that several insect species had developed resistance to Bt raises questions over the longevity of Bt and insect resistance. Bt-based sprays and powders are used to control pests in a number of fruit and vegetable crops within the organic industry. Being a naturally occurring substance Bt is one of a few pesticide sprays the organic industry has at its disposal to control heavy insect infestations when other measures have failed (eg. trap cropping, companion planting, maintenance of a healthy population of predatory insects, etc).

With the widespread planting of transgenic Bt crops the probability of insects developing a resistance to Bt sprays increases. Feldmann et al. (2000) suggests that if these insects infest organic crops farmers will suffer important losses, including the loss of an integral component of their IPM programs, used only as a last resort.

5.0 Discussion

From the evidence presented above, it is clear that there is potential for spillover effects to occur from GM crops to organic agriculture. At present, there is nothing to stop GM crops from being grown alongside organic farms, even though this action will directly impact on the livelihood of organic farmers.

This potential looks set to increase, with the Australian and Queensland Governments being prepared to invest heavily in the bioindustries sector. The federal government is currently expending $250 million per year on GM technologies. Of this 30% is devoted to foods. In Queensland the Premier last year announced the State's 10 year, $270 million Bioindustries Strategy. The strategy aims to provide funding to bioindustry research and development facilities, encourage international bioindustry firms to set up in Queensland, keep the public informed of the benefits of biotechnology and to provide the local work force with the appropriate skills to develop the biotechnology industry in Queensland (Queensland Bioindustries Office 2000).

Within the Central Highlands of central Queensland there is currently 19,785 hectares of land certified for organic grain (wheat, sorghum, sunflowers, and maize) production (Biological Farmers of Australia and National Association for Sustainable Agriculture Australia, pers comm. 2001), including the largest certified organic wheat producer in the Southern Hemisphere. Within the same region 10,000 hectares of GM cotton will be grown this season (Kelly, D. pers comm. 2001). Whilst the threat of GM contamination between these crops is small it does highlight the fact that large areas of established organic farms are having GM crops grown within close proximity and are at risk of experiencing some of the spillover effects discussed earlier in this paper.

It is not clear if the Queensland Government has considered the potential costs to the organic industry, and resulting losses of consumer surpluses if organic foods are not available, in developing the push for the state to embrace biotechnology industries.

5.1 An assessment framework

One standard approach that economists use to assess tradeoff situations is cost benefit analysis. This would be applied where the costs and benefits associated with GM and organic crops, or the further regulation of either, can be estimated and compared. The current growth in both GM and organic agriculture in Australia indicates that there are substantial production benefits associated with each. (For GM crops the benefits may simply be maintaining competitiveness in international markets).

For organic foods, the benefits are largely expressed through market demand factors, indicating that there may be consumer surpluses associated with organic foods. This is unsurprising, given that many people associate organic foods with food safety and health factors (Rolfe 1999). For GM crops, the production benefits are mostly occurring in the form of producer surpluses, as higher yields and lower costs are often associated with these crops. For example, Falck-Zepeda et al (2000) estimate that producers obtained 59% of the surpluses deriving from BT cotton in the United States. The gene developer received 21%, followed by US consumers (9%), the rest of the world (6%), and the germ plasm supplier (5%).

However, the value of many of the other attributes of food are more difficult to estimate directly from market information. Caswell (1998) reviews the different approaches available to estimate measures for food safety and nutrition. These include avoided cost (of illness) measures, experimental market (eg contingent valuation) measures, conjoint analysis, related market data, liability costs and trade analysis. Experimental market measures may also be applicable to estimate values for other cost factors, such as animal welfare and environmental impact factors.

The combination of such mechanisms offers a framework for assessing the net benefits available to the Australian public from both the biotechnology and organic cropping options. The spillover costs of GM crops on organic farmers that have been outlined in the previous section could be assessed with such methods, and compared to the benefits of biotechnology crops. This would help to determine where the tradeoffs between biotechnology and organic crops exist, and the net benefits of specific regulatory options (such as buffer zones in specific areas, or GM-free regions).

To determine the net benefits of biotechnology and organic crop options, both consumer and producer surplus amounts should be calculated. Consumer surpluses associated with organic foods are likely to arise from perceptions about food safety, nutrition and other process factors. Some outcomes of organic farming (eg some environmental impacts) may depress consumer surpluses. In a similar way, outcomes associated with biotechnology crops are likely to have both positive and negative impacts on consumer surpluses.

Because of the public good aspects of some of these factors, especially those associated with environmental outcomes, data collected from markets will not be sufficient to assess changes in consumer surpluses. Some form of experimental market data will be needed to collect this type of information (Caswell 1998). Further research is needed to explore the applications of techniques such as contingent valuation and choice modelling to food safety issues and food production methods.

5.2 The precautionary principle

The assessment of costs and benefits associated with biotechnology will suffer from the same problems that impede discussions between biotechnology and organic farming sectors – perceptions about risk and uncertainty. Proponents of organic farming tend to view the risks of unforeseen consequences from biotechnology as unbearable consequences, while the scientific community views risks through the prism of Type I and Type II errors.

The scientific community tend to be accepting of some levels of risk as a normal outcome of hypothesis testing (even if they are not very good at informing the public about them). When hypotheses are tested at a 5% level, this means that Type I errors (incorrectly rejecting the true hypothesis) occurs, on average, in every 5 out of 100 cases. There are also Type II errors, where incorrect hypotheses are accepted. This means that even though scientific tests may not establish a link between GMOs and health and environmental concerns, there may be exceptions occurring through the Type I and Type II errors.

In contrast, critics of biotechnology advances view any exceptions as a catastrophe, rather than an acceptable error. This group tend to call for the precautionary principle to be adopted in relation to GMOs, where the use of GMOs would be banned until risks could be shown to be zero. The scientific community developing the biotechnology industry tends to accept risk as a normal outcome of new endeavours. The growth of biotechnology industries indicates that industry and science regards the risks involved in new developments as being outweighed by the possible gains. Taking a precautionary approach to new developments can be evaluated in an economic framework[3]. The relevant question is whether the risks and uncertainties associated with developing GMOs are outweighed by the potential production gains available. The expected outcomes from answering this type of question is that some GMOs might not be allowed, while others are encouraged to proceed. This is exactly the outcomes of existing government regulation, where some GM crops are allowed, while other trials (eg inserting human genes into food items) are banned. Thus there is already some precedent for the precautionary principle to be applied in relation to biotechnology developments.

Although this precedent may exist, there has been little interest from Australian governments in applying the precautionary principle more widely in public policy. Policy is normally framed on addressing known (and quantifiable) risks, rather than unknown (and unquantifiable) ones. Under this approach, there is little weight to the argument that some GMOs should be banned because of unknown risks that scientists have not yet been able to discover. In relation to the potential for spillover effects from GMOs, it is unlikely that the unknown potential without any scientific proof will be substantial enough to change current public policy.

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[3] Some commentators view the precautionary principle as an absolute rule. Rolfe (1995) argues that the (similar) Safe Minimum Standard rule is better cast in a consequentialist framework where the benefits and costs of adopting or not adopting the rule can be assessed.

One problem with this approach is that the bulk of scientific investigations are focused on discovering new benefits of biotechnology, not on looking for possible environmental consequences (Appell 2001). Thus although there may be spillover effects from biotechnology crops to organics, the amount of scientific effort devoted to exploring those effects is small compared to the effort going into developing new biotechnology opportunities. This suggests that current Government policies may be flawed in two ways.

Firstly, they appear to focus public expenditure on developing a new biotechnology industry where the resulting benefits are likely to be mostly private, rather than focusing expenditure on minimising the health and environmental consequences of biotechnology developments, where the benefits would be mostly public ones. Second, regulation regarding the spillover effects of biotechnology crops appears to be tied to achieving a scientific proof of a spillover effect, even though there is little funding available for this type of research to take place. The wider use of a precautionary principle in relation to biotechnology initiatives does not appear to widely canvassed.

However, there is growing international recognition that the scientific approach to biotechnology and food safety issues is not always sufficient. The latest estimates from the United Kingdom for potential deaths from the human form of BSE ranges from 20,000 to 272,000 people (MacKenzie 2000). What value would those victims have placed on a precautionary principle being adopted by industry, scientists and regulators in the early 1990s? In hindsight a precautionary approach could have been justified many times over.

The precautionary principle is being applied to biotechnology issues, with the principal enshrined in the 2000 United Nations Biosafety Protocol regulating trade in genetically modified products (Appell 2001). In application, the principle means that when there are sufficient risks involved, precautionary measures should be taken even if some cause and effect relationships have not been established scientifically.

Under this definition, there are two key elements to determining in an economic framework when the precautionary principle can be used. The first is determining the size of the sufficient risk that will act as a trigger. This is likely to involve harm to human health or the environment, but what levels will be sufficient to act as a trigger? Economists have a role to play in assessing public preferences about where the levels of risk are high enough to justify the opportunity costs involved in stopping biotechnology development.

The second issue to determine is where the levels of scientific knowledge become complete enough to relax the precautionary principle. While some environmentalists treat the precautionary principle as a binding rule, in an economic framework it should only be applied when there are both risks of large unknown impacts and incomplete scientific knowledge. As scientific knowledge about potential adverse outcomes improves, the assessment of risk can take place in the standard institutions that society uses and the precautionary principle can be relaxed. The advantage of adopting this framework is that it provides incentives for the proponents of GMOs to demonstrate that scientific uncertainties have been reduced.

Should the precautionary principle be applied to biotechnology industries in Queensland and Australia? The answer will depend on what the level of risk may be involved, how the public perceives those risks, and what gaps exist in scientific knowledge. Finding new ways of assessing public attitudes to risk and uncertainty involving biotechnology crops are important directions for future research in economics.

6.0 Conclusions

The Australian organic industry has undergone recent and rapid expansion in response to consumer concern over food safety, animal welfare and environmental concerns. The organics industry is growing at 20-30% per annum and generates an annual gross value of $200 million. Similarly the introduction of GMO's into agriculture continues to increase as farmers, responding to production pressures, pursue the efficiency and productivity benefits GM crops offer. In contrast to organic agriculture, growth in the biotechnology sector has been assisted by significant government investment in R,D&E activities. In 2000 the Federal and Queensland Governments announced funding of $520 million in support of bioindustry research. In comparison the organic industry received $1 million.

It is clear that the existence of spillover effects from GM crops pose a serious threat to the future of organic agriculture. Whilst government's in Australia have attempted to manage these risks through the introduction of polices, regulations and additional R,D&E initiatives, experiences to date suggest significant externalities continue to threaten the industry, and may ultimately reduce consumer surpluses through decreased organic production.

In addition to scientists and regulators it is argued that economists have a role to play in addressing public good tradeoffs between the organic and biotechnology industries. Traditionally economists have utilised benefit cost analysis as the primary tool to assess tradeoff situations. Inaccuracies associated with the markets ability to reflect and value public goods has hampered efforts to measure all the benefits and costs associated with organic and GM foods. It is suggested that in combination with benefit cost analysis governments should be investing in new applications of experimental market research to value the cost of spillovers from GM crops to organic agriculture.

Recognising the limitations of hypotheses testing (Type I and II errors) as an acceptable risk assessment framework for biotechnology research, a more appropriate solution may lie in the use of a precautionary principle. The challenge for economists and governments in using the precautionary principle is developing an appropriate economic framework from which to operate. Further work is required assessing public preferences to determine what level of risk should trigger the use of the precautionary principle, and when it might be relaxed.

Developing new tools to assess public attitudes towards risk and uncertainty involving biotechnology crops remains an important future research direction for economists in Australia. One technique that may be useful is Choice Modelling.

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