GM CROPS IN AUSTRALIA: A CRITIQUE OF THE ECONOMIC MODELLING

Stephen Rix and Richard Denniss*

The announcement of the helical structure of DNA on ANZAC Day 1953, and the subsequent development of techniques to genetically modify organisms has resulted in the development of a new industry concerned with the design, production and sale of genetically modified (GM) food crops. In recent years, the development and introduction of new GM food crops onto the world agriculture market has been accelerating. As a major food exporter, Australia is not immune from commercial and political pressure to introduce such crops.

Most GM crops are modified in order to increase their resistance to herbicides and pesticides. These products are often produced by the same firms as those involved in the production of GM crops. Such co-production is significant as it provides an incentive for some producers of herbicides and pesticides to promote the benefits of GM crops. Moratoria on the use of GM crops will therefore reduce profits on herbicide and pesticide sales as well as profits on the sale of GM seed.

Arguments about the introduction of GM crops are occurring in every major agricultural producing country, in multi-lateral institutions (such as the World Trade Organisation), between 'green' advocates and economic policy-makers, and between consumers, producers and processors. Brazil for instance, relaxed its GM import and use restrictions for one year in late 2003. Whether the decision will hold is unclear, with Brazil's Environment Minister and the Catholic church both opposing the

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decision, while Monsanto, a large producer of GM crops, continues to place pressure on the Brazilian Government (*New Scientist*, 2003a).

In the United Kingdom, debate is also proceeding. The most recent research on the impact of GM crops there has shown that modern agricultural techniques – which GM crops require – are a primary cause of environmental damage regardless of whether GM crops are used or not (Coghlan, 2003). Nevertheless, it also showed that 'contrary to its reported claims that herbicide-resistant crops are kinder to wildlife, two out of the three [crops] tested were worse than conventional crops [for biodiversity], while doubts remain about the third' (*New Scientist*, 2003b).

The USA lodged a formal objection to the stricter European GM regulatory regime in June 2003 with the World Trade Organization (WTO) (Leonhardt, 2003). The potential gain to US corporations of overturning the European GM regulatory framework is substantial, with US farm groups saying that the European regulations are 'depriving agricultural businesses of hundreds of billions of dollars a year' (Leonhardt 2003). The USA claimed that the European bans limit the rights of consumers to a free choice about GM foods (Leonhardt, 2003)[1]. Such concerns about the limitations on freedom of choice do not, however, extend to concerns about the promotion of informed choice. For example, the US Trade Department has expressed concern over the decision by the European Union to insist on strict product labelling requirements for products containing GM foods (McCarthy and Castle, 2003).

Responding to the US criticism of the European bans, one Briton was provoked to ask 'Is this the same US that objects to the labelling of GM foods – the very labelling that would enable consumers to make their own decisions? Am I missing something, or does the US administration need to do some more joined-up thinking?' (Bebington, 2003).

Developments in Australia also indicate that GM food technologies have less than overwhelming support. Federally, one of the major policy

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1 The European/US trade dispute is evolving quickly, and our summary of the dispute was written before 30 June 2003

responses has been the Australian *Gene Technology Act 2000*, which prohibits anyone dealing with a genetically modified organisms (eg. for research, manufacture, production, commercial release and import) unless the dealing is licensed by the Gene Technology Regulator for contained use or intentional release into the environment. The Gene Technology Regulator is required to produce a centralised, publicly available database of all GM Organisms (GMOs) and GM products approved in Australia (the Record of GMO and GM product dealings). GM products not already covered by an existing national regulation scheme are regulated by the Office of the Gene Technology Regulator (OGTR) under the legislation (see Department of Health 2003).

In recent years there have been four economic analyses of the economic benefits associated with the reduction or removal of regulations restricting the use of GM crops in Australia – Stone *et al.* (2002); Foster (2001); Foster (2003); and Norton (2003). All four reports conclude that there are economic benefits to Australia associated with reducing restrictions on GM crops (Foster 2003: 1, Norton 2003: Exec Summary, Stone *et al.* 2002: 80, Foster 2001: 6). These reports purport to show that if Australia does not adopt GM technology, Australian farmers' position as competitive suppliers of food to the world would likely be prejudiced.

This paper critically analyses the techniques used in these attempts to determine the economic benefits to Australia of deregulating GM food crops, with particular reference to the Productivity Commission study (Stone *et al.* 2002). It shows that, despite the optimistic assessments of the potential impact of introducing GM crops into Australia, significant doubts exist about the economic analysis quite apart from any doubts about the science (see Coghlan, 2003). It concludes that better modelling and additional data is needed in order to provide policy makers with sufficient information to make well informed decisions about the costs and benefits of introducing commercial GM crops in Australia.

Recent Developments in GM regulation

Concerns over GM food technologies led the New South Wales Government in March 2003 to introduce the *Gene Technology (GM Crop*

Moratorium) Bill, which is 'intended to implement the Premier's announcement on 3 March 2003 that the Government would ban the commercial production of certain genetically modified or GM crops in New South Wales for three years. This was to provide the community with time to evaluate the impacts of the introduction of GM crops on the marketing of non-GM crops' (Newell, 2003: 2).

The National Party representative, Andrew Stoner, supported the Bill, stating:

> ... [T]he farming community in New South Wales is divided over the benefit of releasing GM food crops commercially at this time. The National Party believes there needs to be greater agreement within the farming sector in Australia before we can move into the brave new world of GM food crops, so the National Party is saying 'not yet' to commercial GM food crops in New South Wales. There are too many unanswered questions. Let us hope that the Government's vague and ambiguous Gene Technology (GM Crop Moratorium) Bill provides the opportunity for these questions to be adequately addressed before GM food crops are planted across New South Wales, because if we get it wrong there will be no chance to turn back the clock (Stoner, 2003: 1534).

Given the size of the potential market, agricultural interests in the US are likely to continue in their pursuit of reduced international barriers to the sale of GM crops. While the size of the potential market is uncertain, agriculture groups claim current restrictions are 'depriving agricultural businesses of hundreds of billions of dollars a year' (Leonhardt, 2003).

The developing world is likely to come under the strongest pressure to adopt GM crops, both directly, and indirectly through multi-lateral institutions and from developed nations' aid policies. As noted above, Brazil has already been subject to such pressure. The release in October 2003 by ABARE of *Agricultural Biotechnology: potential for use in developing countries* (Abdalla *et al.*, 2003) attempts to highlight the benefits of GM crops for developing countries. His ABARE report relies on the assumption that productivity gains from GM crops will be twice as high in developing countries as they are in developing countries to 'show' that developing counties will be the major beneficiaries of GM crops.

The pressure on Australian governments to relax restrictions on GM crops also comes from within. It is in this context that the productivity Commission study (Stone *et al.* 2002) is significant.

Modelling of the Economic Benefits of GM Crops in Australia

Estimating the potential economic benefits to Australia of reducing the restrictions on GM crops requires assumptions to be made about consumer and regulator behaviour. Without a clear understanding of these assumptions, it is difficult to appreciate the wide range of values and *a priori* assumptions that are subsequently transformed into 'conclusions' via the modelling process. As with all economists' work, a wide range of assumptions underpins each of the reports we have examined. As Stone *et al.* (2002) provides the most detail on the content and structure of their model, this paper concentrates primarily on their analysis. While it is true that Stone *et al.* (2002) discuss some of the limitations of their report, these limitations are not apparent in their overall conclusions.

The Productivity Commission model, as described by Stone *et al.* (2002), is based on an equilibrium international trade model. A group of equations represent the relationships between significant variables, such as exchange rates, fuel prices, demand for exports and the extent of substitution between imported goods and domestically produced goods. As with any model, the modeller includes some relationships and deems others to be insignificant or immeasurable. The modeller also makes assumptions about the relative strengths of different effects. For example, would a lower price for bread have a big impact on demand, or is the number of sandwiches consumed by an individual each day largely insensitive to the price of bread? Such assumptions may either be based on empirical evidence, follow the judgements made by other authors, or be the judgements of the authors themselves. In this case, the key assumptions concern economies of scale, consumer resistance and farmers' demand for GM technologies.

Economies of Scale

In describing the production process that underpins their model, Stone *et al.* (2002: 41) explicitly reject the existence of economies of scale, stating that 'this model assumes a constant returns to scale production technology'. The assumption of constant returns to scale implies that production costs remain constant as output expands. While this makes modelling easier, it reduces the accuracy of the model for a wide range of industries.

Further, the adoption of a constant returns to scale model is not consistent with the evidence and analysis presented elsewhere in the report. For example, Stone *et al.* (2002) state that:

- 'Costs (of regulation) can also include losses of economies of scale' (p. 36);
- 'The size of additional costs, however, depend on the crop concerned, the volume of production' (p. 36); and
- 'As experience grows, testing procedures improve, and economies of scale are reached...'(p. 38).

While it could be argued that the assumption of constant returns to scale is not significant, Stone *et al.* (2002: 42) are explicit in their views, stating that:

> The assumption of constant returns to scale in production *is significant* because it implies that the percentage change in the price of any commodity will simply equal the weighted sum of the percentage changes in the prices of inputs (emphasis added).

Having set out the case for why economies of scale are important, Stone *et al.* (2002) then assume that they do not exist when conducting their modelling. After then explaining why this assumption is actually significant to the results of the model, the assumption is relaxed once again when interpreting the results of the model:

> Moreover, it is expected that over time, by moving along a learning curve, producers will become better at implementing regulatory requirements. In addition, as the market expands,

> economies of scale will evolve that allow costs to be spread out over a greater amount of output (Stone *et al.*, 2002: 49).

At no point do Stone *et al.* (2002) justify this fundamental inconsistency in their model and its interpretation.

Stone *et al.* (2002), however, are not alone in highlighting the economic benefits associated with increased reliance on GM crops by concealing the assumptions on which the estimates are made. Norton (2003), for example, presents the results of a 'scenario' rather than presenting a fully developed economic model. He bases his scenario on the assumption that 160,000 hectares of GM crops will be planted. Having assumed that the deregulation of GM crops would lead to the planting of an additional 160,000 hectares of GM canola, he then concludes that the economic benefits of deregulating GM crops are equal to $135 million. While this analysis provides an estimate of the economic benefit of planting an extra 160,000 hectares of canola, it does not provide evidence to support the assumption that 160,000 hectares of canola will, in fact, be planted. As with Stone *et al.* (2002), the importance of distinguishing between assumptions and conclusions remains.

Consumer Resistance

Assumptions about the likely acceptance of GM food by consumers in the future are also central to the modelling of the economic benefits associated with deregulation. The Productivity Commission study states that:

> It is assumed that consumer resistance will decline over time, but there will continue to be some consumers (mostly located in developed countries such as the European Union and Japan) who refuse to eat GM foods. However, this niche market is assumed to be small and an expansion of the existing organic market (Stone *et al.* 2002: 49).

Stone *et al.* (2002: 49-51) assume that consumer reluctance to purchase GM foods will decline over the life of their model simulations, falling to 10 per cent by the final period, with regulatory costs assumed to fall to zero. This central assumption appears to be contradicted by the actual development of the market for GM crops in North America. For example, Foster (2001) provides evidence that Stone *et al.* (2002) adopt an unrealistically optimistic position on the likely consumer resistance to GM food, stating:

> Consumer attitudes appear to be hardening against GM products, even in North America where consumption of GM grains has been very large (Foster 2001: 29-30).

Stone *et al.* (2002) use the US as an example of a market where the *relative* level of resistance to GM foodstuffs is low in comparison to other countries such as Japan (Stone *et al.*, 2002: 29-30). However, as Stone *et al.* (2002) note in an appendix, *absolute* levels of concern in the US are quite high:

- 'In 1998/99, 23 per cent of US respondents to a survey, which asked them about plant GM assuming it was not harmful to humans or the environment, said that it was undesirable. Only 54 per cent said that it was desirable;
- In 1999, in response to a question about biotechnology used in agriculture and food production, only 51 per cent were either strongly or moderately supportive;
- In 1999, in response to the question "Would you be more or less likely to buy a food because it was genetically modified?" 57 per cent replied that they would be less likely; and
- In 2000, 50 per cent of US citizens surveyed were negative towards the trend to GM foods' (Stone *et al.* 2002: 88).

The alternative analysis of consumer resistance found in Norton (1998), Norton *et al.* (1998a) and Norton *et al.* (1998b) suggests that consumer resistance to GM crops will remain a substantial barrier to demand in an informed market.

The assertion in the Productivity Commission study that GM foods will come to be increasingly accepted is evidently contentious. If, as appears to be the case, consumer resistance to GM foods is increasing, the assumption by Stone *et al.* (2002) that consumer resistance to GM crops will continue to decline substantially distorts their estimates of the economic benefits of further deregulation.

The Productivity Commission study also assumes that there will be no 'unforeseen health scare, or serious environmental consequences' (Stone *et al.* 2002: 48). Given the extent of uncertainty surrounding the development of GM technology, the report is once again characterised by, and indeed relies heavily upon, a significant assumption that is optimistic, if not unrealistic.

It is also important to note that, while low incomes in developing countries are used as a justification of the assumption that consumer reluctance will be lower in those regions, there is no analysis of the impact of rising incomes in those regions over the next twenty years. Stone *et al.* (2002: 27) state that 'Low income consumers, on the other hand, are highly price conscious, so their purchasing decisions will depend on price differentials between GM and non-GM foods'. If rapid rates of economic growth continue in Asia, and concerns over GM crops continue to increase with income (as assumed by Stone *et al.*, 2002), then demand for GM products may be significantly lower in the future than at present. None of the authors cited in this paper modelled such a scenario.

The assumption of likely consumer acceptance of GM crops in the future is central to the conclusions reached by Stone *et al.* (2002), but it has little empirical support. In fact, it is contradicted by the view that consumer awareness and concern regarding health and environmental issues increases as incomes rise (Stone *et al.* 2002: 27). The significance of the assumption of declining consumer reluctance to consume GM foods cannot be overstated. The US is already committed to GM crops, with 80 per cent of soy beans planted in 2003 being GM (Council for Biotechnology Information 2003). If consumer resistance to GM crops does not decline rapidly in European markets, or if consumer resistance to GM crops rises with incomes in Asia, then the economic benefits associated with switching to GM crops in Australia will be substantially reduced.

Stone *et al.* (2002) give no explanation for failing to model the alternate assumption that consumer resistance may increase over time. Maybe the modellers have a strong belief in a version of Say's Law - that is, that supply creates its own demand – but, if so, it should be made explicit in their analysis.

Farmers' Demand for GM Technologies

A fundamental assumption made by Stone *et al.* (2002) is that demand for GM technologies by farmers and other producers can be analysed solely in terms of efficiency gains, limited only by regulation and consumer resistance. They state that their model was constructed 'so that firms' decisions about whether to use GM or non-GM intermediate inputs of grains and oilseeds in production were based solely on their relative prices' (Stone *et al.*, 2002: 44). It is therefore assumed that farmers operate as rational individual economic agents, motivated solely by short-run cost minimisation and profit motives. Cost reductions and profit increases that are assumed to flow from the cultivation of GM crops are assumed to drive farmers' demand for GM technologies. That is, farmers' demand for GM technologies is assumed to be independent of farmers' own assessments of the claims made by the promoters of GM crops, or of any long run strategic considerations such as the choice to be low cost/low price producers or niche producers capable of selling to high income consumers who demand GM-free goods.

No evidence is presented to support such assumptions about the decision making process of farmers. Indeed, many farmers themselves have expressed concerns about the environmental, moral and financial costs associated with the deregulation of GM crops, both in Australia and overseas. In Australia the Network of Concerned Farmers distributes a wide range of information on the risks associated with GM crops (see Network of Concerned Farmers 2003). In Canada the National Farmers Union has expressed similar concerns (National Farmers Union 2003).

Data Limitations

In order to effectively model the impact of a change in policy it is important to have accurate and timely data for key variables. Much of this data is not available for modellers seeking to determine the costs and benefits of a change in the GM regulation regime in Australia.

In particular, there is inadequate data on the costs to farmers of maintaining segregation between GM and non-GM crops on, and between, farms. In order to achieve such segregation in practice it would be necessary to create and maintain buffer zones, and sterilise harvesting, transport and processing equipment (Network of Concerned Farmers, 2003a). An alternative to sterilisation is the duplication of equipment and infrastructure to ensure that contamination of non-GM crops does not occur. Empirical data on these costs does not exist for Australian agriculture. In order to estimate their likely magnitude, it would be necessary to conduct a comprehensive accounting, engineering and logistical analysis of the Australian agriculture sector. Any attempt to determine the macroeconomic costs and benefits of reducing restrictions on GM crops that does not include such information is likely to substantially underestimate the costs of a shift towards GM food crop production.

There is also a greater need for data on the likelihood of contamination of non-GM crops. Australian climatic conditions and farming practices differ substantially from those in North America. In particular, the absence of snow and the presence of livestock in grain growing areas has the capacity to increase the likelihood of contamination (Network of Concerned farmers 2003b). Accurate estimates of the likely economic benefits to Australia of relaxing regulations on GM crops would need to consider such a risk.

Data on the potential on-farm benefits associated with the use of GM crops is also essential to any attempt to determine the economic benefits associated with deregulation. Stone *et al.* (2002) rely on imputation to determine an estimate of the likely cost savings associated with GM cropping. Their main source of evidence is North American estimates that show yield increase of around six per cent but negligible cost savings. They then impute an additional 1.5 per cent arising from 'other factors' to give a final figure for cost savings of 7.5 per cent.

At the same time, Stone *et al.* (2002: 16) refer explicitly to European assessments which concluded (in respect of GM soy) that 'while cost savings due to the reduced use and cost of herbicides could offset higher seed prices, yields were often lower'. Such conservative findings were not incorporated into the underlying assumptions concerning cost reductions in the subsequent modelling exercise.

In order to accurately determine the economic benefits of GM crops in Australia, actual on-farm cost savings or productivity improvements need to be determined before modelling results can be used as a tool to inform the decisions of policy makers.

Model Requirements for Adequately Informing Policy Makers

In order to ensure that policy makers make good decisions, it is important that those seeking to model the economic costs and benefits of a regulatory change provide clear indications of the assumptions and limitations of the modelling process used and discuss the implications of these shortcomings.

One necessary feature is tests of the sensitivity of results to different assumptions where a high degree of uncertainty surrounds those assumptions. The results of multiple scenarios designed to capture the range of possible values for key variables should be provided. While Stone *et al.* (2002) included a number of different simulations for variables such as consumer and regulatory response, their simulations do not cover the range of plausible scenarios. For example, in modelling consumer resistance to GM foods in the European Union, Australia, New Zealand, Korea and Japan, it was assumed that 25 per cent of the population were resistant to consuming GM foods. North America, China and the rest of the world were assumed to be 'price sensitive', which means that there is no significant resistance among consumers to the consumption of GM foods. Resistance in general is assumed to decline over time. For example:

> The final part of the simulation estimates some 'steady state' economic outcomes once GM technology is firmly in place and accepted by all but a small group of consumers. Regulations are assumed to be relaxed... (Stone *et al.* 2002: 50)

Maybe, but it is also plausible that consumer resistance and government regulation in other countries will either remain stable or increase. Model scenarios which analyse such possibilities would provide both the public and decision makers with more useful information about the possible consequences of alternate courses of action.

The existence of high levels of uncertainty concerning variables such as consumer acceptance and the potential productivity gains from increased reliance on genetic modification requires a wide range of *sensitivity analyses* to be provided in order to provide a more meaningful analysis of the possible costs or benefits from increased reliance on GM crops. That is, rather than publishing results based on their own assessment of the most likely scenario, Stone *et al.*'s (2002) study would have been more informative if it had published the results of modelling under a broader range of plausible scenarios and then made a case for which scenario(s) the authors thought most likely.

In order to inform decision-making analyses also need to take into consideration the *irreversibility* of some decisions. For example, while the decision to remain GM free can be reversed if future evidence suggests that there are net benefits from doing so, the decision to adopt GM foods cannot be easily reversed. This asymmetry in the decision making process, combined with the extent of uncertainty and debate surrounding key variables, has important implications. For example, if policy makers were provided with information on the differential costs and benefits of alternate courses of action under a range of assumptions they would be better able to choose between high and low risk strategies. Without access to information on all likely scenarios, the size of the risks associated with particular decisions remain concealed.

If the costs of postponing the adoption of GM food crops are small, and if concerns about genetic modification diminish (as assumed by Stone *et al.*, 2002), it may be best to delay making an irreversible decision until more information is available. This risk-minimising strategy is probably optimal where the benefits associated with being an early adopter of GM food crops are small. Such risk assessment is, however, impossible when modellers focus their analysis entirely on their own subjectively-determined 'most likely' scenario.

Alternative Principles for Regulation

How to design the most appropriate regulatory structure for GM food crops? There are two quite different principles – the notion of 'substantial equivalence' and the 'precautionary principle'. The former principle suggests that, if a GM product is substantially equivalent to a non-GM product, then the same regulatory approach should apply to them both. This has been the dominant approach in the USA.

The precautionary principle, on the other hand, would require the manufacturer of GM foods to prove that there are no additional risks associated with the production or consumption of GM products. Under the Australian *Gene Technology Act 2000* it appears that the precautionary principle should apply, as the regulator is required to assess all risks related to the use of GM products. However, substantial equivalence has, to date, been used as the starting point for risk analysis in Australia, with reviews of the existing literature being used to search for evidence of likely risks. Such an approach is problematic as it precludes an analysis of systemic risk associated with the adoption of GM crops and because much of the existing evidence has been produced by GM producers.

Alternatively, a regulatory 'half-way house' can be constructed by demanding full disclosure at all stages of production and distribution. One term for such a regulatory system is Segregation and Identity Preservation (SIP). A discussion of these different regulatory approaches is provided in a report prepared by the European Commission (2000).

If the precautionary principle is applied, all regulatory costs are assumed by the GM industry because the industry itself must show that it poses no risk. If the substantial equivalence model is applied, however, there are no regulatory costs incurred by the producers or distributors of GM foods. The distribution of the costs of SIP regulation – which can be considerable – is a major issue for both proponents and opponents of the commercialisation of GM foods. Foster (2001) recognised this concern when he said that:

> The next generation of GM crops is likely to offer significant benefits in terms of quality. However, if the problems of

> consumer acceptance of GM foods require elaborate identity preservation arrangements, then these benefits could be largely negated (Foster, 2001: 6).

The distribution of the regulatory costs will play an important role in defining the development path of the GM food industry.

The decision to prefer substantial equivalence over the precautionary principle is a decision about risk preference, not about efficiency. Economic theory and modelling has little to offer decision makers in choosing between such regulatory approaches. However, if the precautionary principle is preferred it may be necessary to amend the *Gene Technology Act 2000* in order to explicitly exclude reliance on the principle of substantial equivalence, thereby shifting the onus of proof onto producers who would be required to show that, beyond reasonable doubt, their products pose no significant risks.

Conclusions

The development of GM food technologies has created two separate problems for policy makers. First, they must consider how to deal with the environmental risks associated with the potential for GM organisms to contaminate the environment through pollen dispersal. Second, they must decide how the potential economic costs and benefits associated with GM crops should be assessed.

The precautionary principle has long been advocated in relation to environmental risks in the case of policies related to the regulation of GM foods. The same principle appears equally applicable in considering economic costs and benefits. That is, given that any decision to deregulate GM foods is irreversible, the optimal strategy would appear to be to wait until additional information about the likely economic benefits and consumer acceptance is available before irreversible decisions are made.

The assessments of economic benefits in existing studies such as that undertaken by the Productivity Commission do not rely on such an approach. On the contrary, a narrow range of optimistic assumptions about both cost savings and consumer acceptance of GM foods has been used as the basis for the estimation of the economic benefits that would flow from the deregulation of GM food production in Australia. If the objective of such analyses is to provide policy makers with information to inform decision-making then a wider range of assumptions needs to be considered. The subjective assessments of variables such as consumer acceptance and likely cost savings should be clearly distinguished from more objectively determined variables such as price and import elasticities.

The lack of critical data and the flaws in the modelling processes described in this paper lead us to conclude that the existing estimates of the economic benefits from the introduction of GM crops in Australia are likely to overestimate the potential gains. In the absence of accurate data, those seeking to estimate the economic benefits of GM crops should ensure that they provide results for the whole range of plausible values for variables such as consumer acceptance, on-farm cost savings and regulation costs.

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