Centre for International Economic Studies

Discussion Paper
No. 0408

GM Food Crop Technology and Trade Measures: Some Economic Implications for Australia and New Zealand

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November 2004

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CIES DISCUSSION PAPER 0408

GM Food Crop Technology and Trade Measures: Some Economic Implications for Australia and New Zealand[*]

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[*] Revision of a paper presented at the Annual Conference of the Australian Agricultural and Resource Economics Society, Melbourne, 11-13 February 2004. We acknowledge with thanks funding support from Australia's Rural Industries Research and Development Corporation and the Australian Research Council. We have benefited from Kym Anderson's earlier collaboration with Chantal Nielsen and Sherman Robinson. We also are grateful for the support provided by Susan Stone, then of the Productivity Commission, in sharing data used for their GTAP model aggregation. This paper draws on a much longer report for RIRDC (Anderson and Jackson 2004). Views expressed and any remaining errors are our own

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Abstract

How much might the potential economic benefit from a farm productivity boost associated with crop biotechnology adoption by Australia and New Zealand (ANZ) be offset by a loss of market access abroad for crops that may contain genetically modified (GM) organisms? This paper uses the global GTAP model to estimate effects of other countries' GM policies without and with ANZ farmers adopting GM varieties of various grains and oilseeds. The gross economic benefits to ANZ from adopting GM crops under a variety of scenarios could be positive even if the *de facto* moratorium on imports from GM-adopting countries by the EU was maintained, but not if Northeast Asia also applied such a ban. From those gross economic effects would need to be subtracted society's evaluation of any new food safety concerns and negative environmental externalities (net of any new environmental and occupational health benefits).

JEL codes: C68, D58, F13, O3, Q17, Q18

Key words: Biotechnology, GMOs, regulation, trade policy, computable general equilibrium

1. Introduction

Genetically modified organisms (GMOs) are the focus of much attention in world food markets. GM food crop technology is claimed to have great potential for the world's farmers and ultimately consumers, following initial success with GM cotton varieties. Benefits for farmers could include greater productivity and less occupational health and environmental damage (e.g., fewer pesticides), while benefits to consumers include lower food prices and, potentially, enhanced attributes (e.g., 'nutriceuticals'). Despite those potential benefits, GMOs are attracting a high degree of attention among some consumer and community groups concerned about their potentially adverse impacts on food safety (e.g., 'Will they cause cancer?') and the environment (e.g., 'Will they lead to pesticide-resistant superweeds? Will we end up with just a handful of crop varieties supplied by even fewer multinational seed forms?). Numerous governments are responding to those concerns, typically in conservative, command-and-control ways such as placing a moratorium on the production and/or use (and hence importation) of products containing GMOs (as the European Union (EU) did in October 1998) or, in cases where permission is granted to grow or sell certain GM crop varieties, mandating strict GMO labelling laws that necessitate expensive segregation and identity preservation systems to be used throughout the supply chain (as the EU imposed in April 2004 as a replacement for its *de facto* moratorium).

In this atmosphere, exporters of food products understandably fear that they will find customers in food-importing countries discounting or refusing to buy their products if even a subset of the exporting country's farmers adopt GM technology. The experience after October 1998 when the EU imposed its *de facto* moratorium vindicates that concern because, as a result, the US's share of the EU's maize imports fell to virtually zero (from around two-thirds in the mid-1990s), as did Canada's share of EU canola imports (from 54 per cent in the mid-1990s – see www.affa.gov.au/gmmarkets). So while these GM-adopting countries[1] apparently have benefited in terms of lower production costs, they have lost market share to GM-free suppliers, including to Australia in the case of canola.

Food-exporting countries such as Australia and New Zealand (hereafter ANZ) thus need to weigh the potential economic (and any environmental) benefits from biotechnology development against any negative environmental risks associated with producing GM crops, any additional costs of segregation and identity preservation through the supply chain to avoid adventitious (accidental) presence of GM varieties in non-GM shipments and allow consumers to choose between foods with and without GMOs, any discounting and/or loss of market access abroad for conventional counterparts to those specific crops which may contain GMOs, and any discounting and/or loss of market access abroad for other farm products because of what GM adoption does for ANZ's generic reputation as a 'clean, green' and 'safe food' producer.[2]

Pending such analysis, health ministers in Australia and New Zealand have agreed to err on the side of precaution and introduce strict regulations concerning GMOs. As from mid-2001, Food Standards Australia New Zealand requires that GM foods cannot be supplied to the domestic market unless approved (20 had been approved as at August 2001), and mandatory labelling is required for all approved GM foods including processing aids (but not animal feeds) that contain GM protein or DNA or that have altered characteristics.[3] This is one of the most stringent food safety regimes in the world outside the EU, which means that satisfying domestic sales requirements makes it possible for ANZ exporters to satisfy most other countries' requirements (even though different labels will be required for different markets). On the production side there are strict controls too. By mid-2004 Australia had approved GM production only for canola (just two varieties, in addition to cotton and carnations). However, like New Zealand, most State governments in Australia have imposed moratoria on GM food crop production in their jurisdiction.

To date there has been few simulation analyses of the economic benefits and costs to ANZ farmers and the economy generally of GM policies not just at home but also abroad. Partial equilibrium studies of adoption at home have been undertaken by Foster (2001) for GM canola and wheat in Australia and by Saunders and Cagatay (2003) for four products in New Zealand, and Stone et al. (2002) provide a general equilibrium analysis (using the global GTAP model) for GM coarse grains and oilseeds adoption in Australia. The present study builds on those earlier studies in several respects: among other things, it uses the same general equilibrium GTAP model as Stone et al. but a more recent version of the GTAP database and examines a wider range of GM-adopting countries and of policy responses; it examines not just coarse grains and oilseeds but also prospective GM versions of wheat and rice (to provide a partial estimate of the opportunity cost of not approving their commercial release); it examines within the same modelling framework the effects on both Australia and New Zealand without and then with them adopting GM crop varieties; and it looks at effects on not only national economic welfare but also the real net income of farm households in both countries (as distinct from the partial equilibrium notion of producer welfare).

The next section of the paper provides details of what the GTAP model of the global economy can and cannot do in exploring the production, trade, price and national economic welfare effects of GM technology and trade measures. Results are presented in Section 3 for a range of scenarios that vary by GM crop type, the set of adopting countries, and various policy responses to GM technologies. Key caveats are discussed in Section 4 before drawing out policy implications for Australia and New Zealand in the final section.

2. The GTAP model and modifications

The well-received Global Trade Analysis Project (GTAP) model of the global economy is used to provide insights into the effects of GMO technology adoption in some sets of countries without and then with trade policy responses in two other sets of countries. Version 5.4 of the GTAP database, released in late 2003, is used for these applications. It draws on global economic structures and trade flows of 1997. The GTAP model has been aggregated to depict the global economy as having 17 regions (to highlight the main participants in the GM debate), and 14 sectors (with the focus on the primary agricultural sectors affected by the GM debate and their related processing industries).[4] Building on a recent Productivity Commission study (Stone et al. 2002), our modification of the GTAP model captures the effects of productivity increases of GM crops, consumer aversion to consuming GM products, and substitutability of GM and non-GM products as intermediate inputs into final consumable food.

The GTAP version we use is a standard economy-wide model that does not include environmental externalities, so the welfare consequences of any such externalities are not measured. This is what is typically done in empirical trade analysis, other in those exceptional studies that seek to focus explicitly on the environmental effects of trade,[5] because capturing the environmental effects is an art in itself and there is typically great uncertainty as to the linkages. That is certainly true in this case, where it is not even clear whether the net environmental effects would be positive or negative. On the one hand, many GM crop varieties have some attributes that are more environmentally friendly than their conventional non-GM counterparts. They also are less dangerous to farmers where they require reduced applications of pesticides.[6] On the other hand, there is concern that some long-term and possibly irreversible negative environmental effects might show up in the future – although a recent comprehensive report to the UK Government by a scientific committee could not find any significant evidence of such adverse effects, nor reasons to expect they will emerge (King 2003).

The welfare calculus in the GTAP model, as in all such models, is also unable to value the consumers' imagined risk in eating foods that may contain GMOs (Pollack 1998). The model's incapacity to include this, as with the above-mentioned production externalities, does not negate the value of using GTAP for current purposes, but it does affect the interpretation of the welfare results. That is, they provide a measure of the opportunity cost of not deregulating, which society can then weigh against its subjective valuation of avoiding real or imagined externalities and risks (and the cost of any public research needed to adapt available GM technology to suit ANZ conditions).

2.1 Production

In the GTAP simulations reported below we assume 45 per cent of US and Canadian coarse grain production is GM (its recent share), while Latin American countries, Australia and New Zealand, if they adopt, are assumed to adopt GM coarse grains at two-thirds the level of the US (i.e. 30 per cent of their coarse grain production is GM) and all other countries are assumed to adopt GM coarse grains at one-third the level of US adoption (i.e. 15 per cent of their coarse grain production is GM).[7] The latter assumptions reflect the facts that maize, soybean and canola are smaller shares of coarse grain and oilseed production in the countries yet to adopt GM varieties, and that the smaller plot size of fields in all but Australia make the technology less cost-effective because more buffer zoning is required per hectare of GM crop in densely farmed regions. Similarly, we also assume that 75 per cent of oilseed production in the US, Argentina and Brazil is GM, while Canada, other Latin American countries, Australia and New Zealand adopt at two-thirds the extent of the major adopters and the remaining regions adopt at one-third the extent of the major adopters.

For rice, major prospective adopters including the US, China, India, and all other Asian countries are assumed to produce 45 per cent of their crop using GM technologies (the same share as GM coarse grain in adopting countries). All other regions, being less rice-intensive are assumed to adopt at two-thirds this rate (i.e. 30 per cent of their rice crop is GM). GM wheat adoption is assumed to occur to the same extents as assumed for coarse grain adoption in the various regions.

To distinguish GM from non-GM productivity, the adopting sectors are each sub-divided into GM and non-GM product, and an output-augmenting, Hicks-neutral productivity shock is implemented on the GM varieties of these commodities to capture their higher productivity. Following Stone et al. (2002), these model simulations assume that total factor productivity is higher for GM than for non-GM varieties by 6 per cent for oilseeds and 7.5 per cent for coarse grains; in the prospective cases of rice and wheat, a conservative 5 per cent difference is assumed.[8] This means GM technology uniformly reduces the level of primary factors needed per unit of output.[9] In the constant-elasticity-of-substitution production nest, producers choose between imported and domestic inputs according to the model's Armington (1969) elasticities, in deciding whether or not to use GM or non-GM intermediate inputs in their production of final goods.

Some earlier studies have assumed GM adoption requires the introduction of segregation and identity preservation systems, and have suggested their cost could amount to as much as 15 per cent of the farm gate price of the GM product (e.g., Burton et al. 2002). But in practice such costs may be borne partly by producers of non-GM varieties, and the fixed cost of their introduction would be amortised. We expect in the steady state that the annual cost would be very small, bearing in mind that segregation and identity preservation are not new and are becoming more common as consumers demand ever-greater product differentiation by variety, by quality and (for various food safety and environmental reasons) by place and method of production. For those reasons, and because in our policy response simulations we assume countries banning GM supplies exclude imports from GM-adopting countries of both the GM varieties and GM-free substitutes, we do not include segregation and identity preservation costs.

2.2 Consumption

Consumers' knowledge and acceptance of GM foods varies around the world (Gaskell et al. 1999, McGarry et al. 2002; James and Burton 2003; Lusk et al. 2003). In order to capture consumer's differing aversion to GM products, the traditional GTAP demand structure is altered. Specifically, elasticities of substitution in consumption between GM and non-GM varieties of each product are specified to be reasonably high in the current GM-adopting countries (where there is very little segregation and identity preservation) and in developing countries, but much lower in regions where consumers are more averse to GM foods (most notably the EU).

2.3 Simulations

The simulations reported below are selected from many possibilities to show how different combinations of crop choice, country adoption and policy responses alter economic impacts of GM technologies. Three sets of crop adoption scenarios are considered: a core set, involving just coarse grain and oilseeds for current adopters plus ANZ, followed by two variations on the core simulations: one is optimistic about the acceptance of GMOs (so it adds extra GM crops and adopting countries), the other is pessimistic (so it considers the consequence of a spread to Northeast Asia of the EU's policy of banning imports from GM-adopting countries).[10]

The first or core set of simulations examines the implications of adoption of GM coarse grains and oilseeds by the US, Canada and Argentina without and with ANZ also adopting, and without and with an EU moratorium.[11] These scenarios are then compared with all countries of the world adopting GM varieties of these crops, to get an idea of the global economic benefits foregone annually because of the continuing reticence in the EU and elsewhere to embrace this new technology (***Simulations 1a to 1e***).

GM varieties have been developed for the world's other two major food crops, rice and wheat, to the point where their commercial release would quickly follow if there was a decision by major governments to approve them and there was sufficient evidence that consumers would be willing to buy foods produced with them. The most likely place where those changes might occur is in China, where the government appeared close to reaching an approval decision in 2004 but has again deferred the matter for another year. India also is very actively examining the issue (Pray, Bengali and Ramaswami 2004), and would likely soon follow a positive decision by China. The US and Argentina may well then join in. We therefore ran a second set of simulations to examine the impact of adding GM rice and wheat adoption in North America and Argentina to their adoption of coarse grains and oilseeds, together with China and India also adopting GM varieties of all four groups of crops. Paralleling the first set of simulations, there are five scenarios in this set too: adoption without and with ANZ also adopting, and without and with an EU moratorium, plus one with all countries of the world adopting GM varieties of these crops (***Simulations 2a to 2e***).

The other variant on the first set of simulations recognises that the EU moratorium is tempting other countries to adopt a similar approach to GM food products. A pessimistic scenario from the viewpoint of GM adopters would involve an import moratorium also in Northeast Asia. In the third set of simulations we therefore examine the impact of GM adoption of just coarse grains and oilseeds in North America and Argentina in the presence of a GM import moratorium by not only the EU but also China, Japan and South Korea. Again that is run first without and then with ANZ adopting GM varieties of those crops. This pair of scenarios highlights the tradeoff for ANZ producers and governments between productivity growth via GM adoption and the benefits of remaining GM-free given actual EU and (in this case) assumed Northeast Asian reluctance to import crops produced in GM-adopting countries (***Simulations 3a and 3b***).

These simulations, which are summarized in Table 1, are clearly only a small subset of possible simulations, but they are chosen to illustrate major issues relevant to Australia and New Zealand.

[insert Tables 1 and 2 about here]

3. Results

3.1 Quantity and price effects

To examine the impacts of these various adoption patterns on ANZ agricultural sectors, Table 2 reports the production, price and trade impacts of US, Canada, and Argentina adopting GM varieties of coarse grains and oilseeds without and with the EU moratorium, alongside the same scenarios but with ANZ also adopting those GM varieties (columns 1 and 2 versus 3 and 4).[12] If ANZ choose not to adopt GM varieties, and there had been no moratorium by the EU, Australia's production and net exports of not only coarse grains and oilseeds but also of meat (and other livestock) products fall, because domestic prices of these products are lowered by the greater competition resulting from the technology shock in the Americas (column 1 of Table 2). The same is true for New Zealand, although with smaller orders of magnitude (shown in parentheses in Table 2). The EU, however, has banned imports of most coarse grain and oilseeds from North America and Argentina because of their GM content, providing greater opportunities for ANZ and other food exporters to supply European markets. That ban reduces the extent of the reduction in Australian production and net exports of these products but it does not eliminate the negative effect of greater competition from GM adopters abroad. Even for New Zealand it barely is sufficient to neutralize the production effect of GM adoption abroad (column 2 of Table 2).[13]

If ANZ were to choose to join the GM adopters, Australian coarse grain production would expand instead of contracting and, if there were no EU moratorium, oilseeds production would fall much less. Lower domestic prices for these products induce increases in domestic consumption but those increases would not be enough to prevent coarse grain net export earnings from rising instead of falling (compare columns 1 and 3 of Table 2). Oilseeds net exports would fall less in the absence of an EU moratorium but not in its presence, should Australia adopt GM varieties not approved in the EU (see second-last row of Table 2).

3.2 National trade balance and net welfare effects

The effect on the aggregate trade balance is positive for ANZ in the absence of the EU moratorium and negative in its presence, in line with the sign of the net impact of the productivity growth and policy response on the global economy. The reduction in that trade balance from adopting GM coarse grain and oilseed varieties would be small, however: no more than US$2 million per year for Australia and less than $0.5 million for New Zealand, without or with the EU moratorium (compare columns 1 and 3 or 2 and 4 of the first two rows of Table 3).

[insert Table 3 about here]

The net economic welfare effects on ANZ and other countries for these scenarios are summarized in the lower part of Table 3. GM coarse grain and oilseed adoption by North America and Argentina benefits those countries despite the deterioration in their terms of trade (see below in Table 6) as a consequence of their expanded exports, although less so (especially for Canada) in the case where the EU moratorium continues. The EU and the rest of the world also would benefit, via improved terms of trade, except in the case of the EU moratorium which raises EU domestic prices of farm products and thereby attracts more resources into an already heavily protected EU farm sector. Australia is worse off if it does not adopt but better off if it does, the difference for these commodities being (10 – (-4) =) US$14 million per year in the presence of the EU moratorium but (7 – (-9) =) US$16 million if the moratorium were to be removed. New Zealand's measured economics welfare too is higher with its adoption, by $1-2 million per year. GM adoption by North America and Argentina (with or without ANZ adopting) would benefit the world as a whole by a substantial US$2.3 billion per year if the EU were to impose no barriers to imports of GM products. This represents more than half of the gains that would come from the whole world adopting GM varieties of these products ($4.0 billion – see final column and row of Table 3), reflecting (a) the fact that the adopters produce close to half the world's coarse grain and oilseed and (b) our assumption that the broadacre nature of production/large farms in the adopting countries ensures GM crops would represent a larger proportion of production there than in the rest of the world.

In the first set of variations on the core simulations, wheat and rice are added to the set of GM crops and China and India are included in the set of GM-adopting countries. That lowers ANZ production, prices and net exports of coarse grain and oilseeds even more than in the first set of simulations (because of greater competition from the expanded supply of wheat and rice), in addition to having negative effects on ANZ wheat and rice markets. The net economic welfare effects of adding these commodities and countries to the crop adoption set are non-trivial. Estimated global economic welfare improves, if there are no trade policy responses, by $4.3 billion instead of $2.3 billion per year (compare column 1 in Tables 3 and 4). The US, Canada and Argentina gain little extra, however, because their productivity gains are almost offset by a worsening of their terms of trade (see Table 6 below) as a consequence of their additional productivity and of extra global supplies following China and India's adoption. When ANZ do not adopt GM varieties, Australia loses around twice as much in this extended adoption scenario regardless of the EU policy stance while New Zealand loses almost no more (since it produces almost no wheat and rice). If ANZ adopt GM varieties of coarse grains, oilseeds, rice and wheat, Australian economic welfare would improve more than in the coarse grain/oilseed adoption scenario in the absence of the EU moratorium, while New Zealand's would be no different (compare columns 3 in Tables 3 and 4).

[insert Table 4 about here]

In the presence of the EU moratorium, on the other hand, Australia's welfare would improve less than in the coarse grain/oilseed adoption scenario (but still improve) while New Zealand's would improve more (compare columns 4 in Tables 3 and 4). The reason for the difference between Australia and New Zealand in that latter comparison is because of the lowered price of wheat and rice in international markets, which alters the terms of trade negatively for Australia but slightly positively for New Zealand (to be shown below in Table 6). In other words, Australia would gain from joining the adopters of GM varieties of these four crops even if the EU moratorium were to continue indefinitely, provided the value Australians place on any adverse environmental effects of GM production (net of any positive environmental and farmer health effects such as from reduced pesticide use) is no more than US$7 per capita per year (assuming total annual benefits are spread equally among Australia's population). For New Zealand, however, that figure is less than 50 US cents per capita.

The above results understate the impact of current EU policies on ANZ and other countries because the EU moratorium has encouraged the adoption of GM trade restrictions in other countries. What would be the impact if Northeast Asian countries are assumed to have followed the policy example of the EU? This can be seen from Table 5, which shows results from our third set of simulations in which the EU moratorium on trade in GM coarse grains and oilseeds is extended to include China, Japan and Korea. That broadening of the moratorium alters somewhat the incentives for Australia, but not New Zealand, to adopt GM varieties (first two rows of Table 5). The reasons become clear in Table 6. Specifically, row 11 of Table 6 (***Sim 3a***) shows that the positive terms of trade impact Australia experiences by not adopting GM varieties and thereby maintaining market access to these important markets ($111 million) dominates the negative allocative efficiency impact (-$15 million), resulting in a net positive welfare outcome (US$ 96 million). If Australia chooses to adopt and thereby loses access to not just European but also Northeast Asian markets, on the other hand (***Sim 3b***), the negative terms of trade impact (-$46 million) overshadows the potential benefits from technical change ($17 million) and improved allocative efficiency ($16 million) to yield a net loss of $13 million per year (row 12 of Table 6).[14] The difference for Australia in this case between Sims 3a and 3b (that is, between adopting and not adopting in the presence of a broadened moratorium) is thus $109 million per year. (Our unreported results show that one-fifth of that difference is due to China, the rest to Japan and Korea.) For New

Zealand, by contrast, its coarse grain and oilseed industries are too small for GM adoption there to make much difference (compare the final two rows of Table 6).

[insert Tables 5 and 6 about here]

In short, the estimated payoff to ANZ from GM adoption is positive in the first two sets of scenarios (the second involving GM adoption by two more large countries and two more crops than is currently the case) but smaller in the presence of the EU restriction on imports. Moreover, if the EU's stance were to encourage Northeast Asia also to adopt a moratorium on imports from GM-adopting countries, the payoff to ANZ from adopting could switch to slightly negative.

3.3 Real net farm household income effects

These net national welfare gains are the sum of the effects for food producers and consumers, assuming no net externalities on the production side and no food safety concerns on the consumption side of the market. What are the effects on just farm household incomes in ANZ? To estimate them, we assume ANZ farm households earn 75 per cent of their net income from farm activities (half from labour, one-eighth from land and the rest from physical capital) and the other 25 per cent from non-farm activities (one-third from wages and two-thirds as returns to physical capital). With those earnings shares and the changes in factor prices generated by the GTAP model we can estimate the changes in net earnings of farm households. To convert them to changes in real net income we assume ANZ farm households have the same spending pattern as the community average and so we subtract the change in the consumer price index. The resulting estimates are shown in the final column of Table 6.

In no cases are these effects more than 1 per cent. This result is not surprising because these crops contribute only a small fraction of net incomes of farm households in Australia and even less in New Zealand. Also, the terms of trade changes from GM adoption abroad are only small; and in the cases of adoption at home, the assumed productivity growth is just 5 to 7.5 per cent and is applied to only 30 per cent of production of coarse grain, wheat and rice and 50 per cent of oilseeds. Even so, the results suggest ANZ farmers would be slightly worse off from adopting versus not adopting GM crops, implying that ANZ non-farm households would need to compensate farmers out of their gains from the fall in food prices if ANZ farmers were to be end up no worse off from embracing this technology.[15] The difference is especially marked in the case where Northeast Asia copies the EU moratorium: in that scenario, Australian farm households would be 0.8 per cent better off if they do not adopt GM coarse grain and oilseed varieties but 1 per cent worse off if they do (rows 11 and 12 of Table 6).

4. Caveats

The myriad assumptions that are necessary to run the above simulation experiments make the inclusion of our results from systematic sensitivity analysis impractical in a journal-length paper. One key assumption that has already been mentioned is that, in the absence of relevant evidence, the disutility from any negative environmental risks is offset by positive environmental and occupational health benefits associated with producing GM as compared with non-GM crops.

We also assume that there is no discounting and/or loss of market access abroad for other food products because of what GM adoption does for a country's generic reputation as a producer of ‘clean, green, safe food’. This understates the gains to New Zealand of staying GM free because if Australia were to allow GM adoption then the demand for food products in general from New Zealand may increase at Australia’s expense in so far as the two countries are currently seen as close alternative suppliers of ‘clean, green safe food’ (and vice versa for Australia if only New Zealand were to adopt).

We assume too that there is no need for segregation and identity preservation (SIP) through the supply chain to allow consumers to choose between foods with and without GMOs. This means we have overstated the gains to ANZ from GM adoption at home because, given the strict labelling legislation introduced by both countries earlier this decade, a SIP system for domestic crops would have to be used if GM varieties were to be grown locally. But with SIP cost estimates varying from close to zero to as much as 15 per cent of the crop value, it is not yet possible to judge the extent of that possible overestimation.

We have ignored the owners of intellectual property in GM varieties, and simply assumed the productivity advantage of GM varieties is net of the higher cost of GM seeds. In so far as that intellectual property is held by a firm in a country other than the GM-adopting country, then the gain from adoption is slightly overstated in the adopting country (and understated for the home countries of the relevant multinational biotech companies).

The effects of adoption and of policy responses depend on, among other things, the elasticities of substitution in consumption between GM and GM-free (but otherwise like) crop products. We have assumed those cross-elasticities to be much lower in the EU and to a lesser extent Northeast Asia and ANZ than in the current GM-adopting countries and developing countries. But because of the large size of those latter markets it turns out that varying the EU's elasticities makes little difference to relative prices and hence to the overall welfare results (see the sensitivity analysis reported in Anderson et al. 2002).

Consumer welfare also depends on the imagined risk associated with consuming foods that may contain GMOs. Unfortunately we have no way of evaluating what that loss of welfare would be in the EU if/when GM products are allowed to be sold there (Pollack 1998). To date it appears there is no scientific evidence that GM food is unsafe (King 2003), and there is evidence from experimental economics to suggest consumers are less inclined to discount GM foods when given more information about the risks (Lusk et al. 2004). Nonetheless, the estimated welfare cost of the EU's moratorium is overstated to the extent that EU consumers value the knowledge that they have not been consuming food that may contain GMOs.

The technology shocks in our simulations assume a uniform increase in productivity of all factors used in GM crop production. We retained that assumption because it turns out to make little difference to the welfare results when it is changed to allow some factors to be saved more than others or some intermediate inputs such as pesticides to be needed less by GM crop varieties.

Finally, and perhaps most importantly, the above comparative static modelling assumes GM technology delivers just a one-off increase in farm productivity for that portion of a crop's area planted to the GM varieties. But what is more likely is that, once the principle of GM crop production is accepted, there would be an increase in the *rate* of agricultural productivity growth into the future, so that the present value of future returns from GM adoption may be several times those implied by the numbers shown above.[16]

5. Conclusions

The comparative advantages of Australia and New Zealand in various (GM and non-GM) crops will continue to change not only because of changing consumer attitudes at home and abroad but also as ANZ's trading partners alter their consumer, producer and trade policies and as new (GM and non-GM) crop varieties appear. Evidently plenty of markets for GM crops exist, as the three first GM-adopting countries – the US, Canada and Argentina – still account for high shares of global exports (80 per cent for maize, 64 per cent for soybean and 42 per cent for canola in 2002). Even so, ANZ's benefits from adoption depend on the extent to which GM products are accepted by ANZ's current major trading partners, as well as on how well segregation and identity preservation (SIP) is handled. For that reason, recent debates over whether to approve GM canola production in Australia suggest production is unlikely to be approved until a cost-effective SIP system is in place to allow co-existence of non-GM and GM varieties (Parliament of South Australia 2003; Lloyd 2003). Several States of Australia, like New Zealand, continue to delay approval because they perceive insufficient economic benefit from GM crops to warrant the cost of the necessary co-existence system (which will fall more on non-GM producers, the smaller the share of GM varieties in total output), of the expected loss that would result from a downgrading of their region's status as a 'clean, green, safe food' supplier domestically and abroad, and of insurance to cover the risk of adventitious presence of GM varieties in non-GM crop shipments.

These cautious approaches are understandable while only maize and soybean were ready for adoption, while consumer aversion remained high, and where SIP systems were undeveloped. However, a ban on GM production may be less economically desirable as and when these conditions change, at least for Australia. GM yield-increasing varieties of canola suitable for Australian conditions are now available and two herbicide-resistant ones have been approved by the Office of the Gene Technology Regulator, and new wheat varieties have also been developed by CSIRO that are drought tolerant and exhibit high tolerance to some common pests (CSIRO 2003). Also, consumers are showing more tolerance of GMOs where labelling laws are in place, particularly as they learn of the prospects for building in attributes desired for health, etc. reasons. And SIP systems are gradually becoming more common and cost-effective in response to consumers seeking ever-more product information in general on food labels. Hence while the above analysis does not provide strong reasons for removing current ANZ restrictions, the benefit-cost calculus associated with relaxing the moratoria on the commercial release of GM varieties will continue to change over time and so needs to be kept under review.

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Table 1: Simulation scenarios considered

Scenario:	US, CA + ARG adopt GM coarse grain and oilseeds	ANZ adopt GM coarse grain and oilseeds	US, CA, ARG, CHINA and INDIA adopt GM coarse grain, oilseeds, rice and wheat	ANZ adopt GM coarse grain, oilseeds, rice and wheat	EU bans imports of affected crops from GM adopters	Japan, Korea and China ban imports of affected crops from GM adopters	All countries adopt GM coarse grain and oilseeds	All countries adopt GM coarse grain, oilseeds, rice and wheat
1a	X							
1b	X				X			
1c	X	X						
1d	X	X			X			
1e							X	
2a			X					
2b			X		X			
2c			X	X				
2d			X	X	X			
2e								X
3a	X				X	X		
3b	X	X			X	X		

Table 2: Australian (and New Zealand)[a] production, price and trade impacts, under various GM adoption and policy response scenarios

(percentage changes, weighted average of GM and GM-free varieties)

	US, CAN, and ARG adopt		US, CAN, ARG, and ANZ adopt	
	(and no import bans)	With EU moratorium	(and no import bans)	With EU moratorium
	Sim 1a	***Sim 1b***	***Sim 1c***	***Sim 1d***
Production volume				
Coarse grains	-0.2 (-0.2)	-0.1 (0.0)	0.4	0.2
Oilseeds	-3.2 (-0.6)	-2.3 (0.2)	-0.8	-3.7
Meat products	-0.1 (-0.2)	-0.1 (0.0)	-0.1	-0.1
Domestic market prices				
Coarse grains	-0.1 (-0.0)	-0.1 (-0.0)	-1.2	-1.2
Oilseeds	-0.1 (-0.0)	-0.1 (-0.0)	-1.0	-1.0
Meat products	-0.0 (-0.0)	-0.1 (-0.0)	-0.1	-0.1
Import volume				
Coarse grains	7.0 (2.2)	8.0 (2.8)	-4.5	-3.7
Oilseeds	6.7 (1.9)	8.1 (0.9)	2.7	3.8
Meat products	0.4 (0.7)	0.3 (1.3)	0.3	0.2
Export volume				
Coarse grains	-1.0 (-0.9)	-0.8 (18.8)	2.0	0.7
Oilseeds	-4.6 (-4.1)	-3.3 (23.7)	-1.1	-6.0
Meat products	-0.3 (-0.4)	-0.3 (4.3)	-0.3	-0.2

[a] New Zealand percentage changes are shown in parentheses

Source: Authors' GTAP model simulation results.

Table 3: Trade balance and economic welfare effects of GM coarse grain and oilseed adoption by various countries

(US$ million per year)

	US, CAN and ARG adopt		US, CAN, ARG + ANZ adopt		All countries adopt
	(and no import bans)	With EU moratorium	(and no import bans)	With EU Moratorium	(and no import bans)
	Sim 1a	***Sim 1b***	***Sim 1c***	***Sim 1d***	***Sim 1e***
Change in trade balance					
Australia	8	-3	6	-5	5
New Zealand	2	-1	2	-1	2
Change in economic welfare (equivalent variation in income)					
Australia	-9	-4	7	10	2
New Zealand	-5	2	-3	3	-5
Argentina	312	247	312	247	287
Canada	72	7	72	7	65
US	939	628	939	627	897
EU-15	267	-3145	270	-3160	595
Rest of World	714	1029	730	1041	2207
WORLD	**2290**	**-1243**	**2325**	**-1226**	**4047**

Source: Authors' GTAP model simulation results

Table 4: Trade balance and economic welfare effects of GM coarse grain, oilseed, rice and wheat adoption by various countries

(equivalent variation in income, US$ million)

	US, CAN, ARG, China and India adopt		US, CAN, ARG, China and India plus ANZ adopt		All countries adopt
	(and no import bans)	With EU moratorium	(and no import bans)	With EU Moratorium	(and no import bans)
	Sim 2a	***Sim 2b***	***Sim 2c***	***Sim 2d***	***Sim 2e***
Change in trade balance					
Australia	11	-1	6	-4	6
New Zealand	3	-1	2	-2	2
Change in economic welfare (equivalent variation in income)					
Australia	-18	-10	10	5	-1
New Zealand	-6	2	-3	6	-7
Argentina	350	285	350	285	312
Canada	83	-23	82	-25	63
US	1045	754	1047	756	1041
China	841	833	851	842	899
India	669	654	671	656	669
EU-15	355	-4717	363	-4868	810
Rest of World	989	1330	1027	1376	3719
WORLD	**4308**	**-892**	4398	-968	**7506**

Source: Authors' GTAP model simulation results

Table 5: Economic welfare effects of GM coarse grain and oilseed adoption by the US, Canada and Argentina with EU and Northeast Asian moratoria

(equivalent variation in income, US$ million)

	US, CAN and ARG adopt ***Sim 3a***	US, CAN, ARG, plus ANZ adopt ***Sim 3b***
Australia	96	-13
New Zealand	14	16
Argentina	213	214
Canada	-84	-81
US	427	431
EU-15	-3080	-3164
China	-971	-1323
Japan and Korea	-2552	-2645
Other Asia	117	143
Rest of World	1348	1444
WORLD	**-4471**	**-4977**

Source: Authors’ GTAP model simulation results

Table 6: Decomposition of national economic welfare effects and change in real farm household income due to GM adoption under various simulations[a]

(equivalent variation in income, US$ million)

	National economic welfare decomposition				% change in farm h'hold income
	Allocative efficiency impact	Terms of trade impact	Technical change impact	**Total impact**	
Australia					
Sim 1a	2	-11	0	**-9**	**-0.05**
Sim1b	3	-6	0	**-4**	**-0.02**
Sim 1c	3	-16	20	**7**	**-0.10**
Sim 1d	5	-14	19	**10**	**-0.11**
Sim 1e	5	-22	19	**2**	**-0.35**
Sim 2a	4	-22	0	**-18**	**-0.07**
Sim 2b	6	-15	0	**-10**	**-0.04**
Sim 2c	4	-38	44	**10**	**-0.12**
Sim 2d	10	-48	43	**5**	**-0.16**
Sim 2e	8	-51	43	**-1**	**-0.17**
Sim 3a	-15	111	0	**96**	**0.83**
Sim 3b	16	-46	17	**-13**	**-0.99**
New Zealand					
Sim 1a	0	-3	0	**-5**	**-0.05**
Sim1b	0	1	0	**2**	**0.01**
Sim 1c	0	-5	2	**-3**	**-0.10**
Sim 1d	0	1	2	**3**	**-0.07**
Sim 1e	0	-7	2	**-5**	**-0.35**
Sim 2a	0	-6	0	**-6**	**-0.02**
Sim 2b	0	2	0	**2**	**0.01**
Sim 2c	0	-6	4	**-3**	**-0.11**
Sim 2d	1	1	4	**6**	**-0.08**
Sim 2e	0	-10	4	**-7**	**-0.18**
Sim 3a	2	12	0	**14**	**0.07**
Sim 3b	1	14	2	**16**	**-0.01**

[a] See the previous three tables for the descriptions of each of the simulations. The welfare decomposition follows Harrison, Horridge and Pearson (1999).

Source: Authors' GTAP model simulation results

[1] The adoption of GM technology has been most widespread in the production of maize, soybean and canola (key livestock feed ingredients globally), as well as cotton. As of 2002, GM varieties accounted for one-quarter of the area planted to those crops globally (and 4.3 per cent of all arable land), having been close to zero prior to 1996. But most of them are grown in Argentina, Canada and the United States, where that GM share is more than 60 per cent (James 2003).

[2] Australia and New Zealand also have a stake in the current and possible future WTO dispute settlement cases on GMOs, bearing in mind the risks this issue brings to the rules-based global trading system in general and the WTO's farm trade reform agenda in particular. These WTO issues are not discussed in this paper but are in, for example, Anderson and Nielsen (2001), Sheldon and Josling (2002), and Isaac and Kerr (2003).

[3] Excluded from that definition are highly refined foods, processing aids (such as enzymes used in cheese and brewing) and additives that lost their GM protein or DNA during processing, food prepared by restaurants and takeaways for immediate consumption, GM flavourings up to 0.1 per cent by weight, and foods, ingredients or processing aids that have GMOs present unintentionally up to no more than 1 per cent by weight per ingredient.

[4] The GTAP (Global Trade Analysis Project) model is a multi-regional, static, applied general equilibrium model based on neo-classical microeconomic theory which assumes perfect competition, constant returns to scale and full employment of all factors of production whose aggregate supply remains constant. International trade is described by an Armington (1969) specification (which means that products are differentiated by country of origin). See Hertel (1997) for comprehensive model documentation and Dimaranan and McDougall (2002) for the GTAP Version 5 database used here. The model is solved with GEMPACK software (Harrison and Pearson 1996). Welfare decomposition follows Harrison, Horridge and Pearson (1999).

[5] See, for example, Beghin, van der Mensbrugghe and Roland-Holst (2002).

[6] The occupational health benefits of GM crops has been clearest in the case of cotton, particularly in developing countries (Hossain et al. 2004).

[7] These and the following base-case assumptions synthesize estimates from a variety of sources including the European Commission (2001) and James (2003).

[8] See Marra, Pardey and Alston (2002) for empirical evidence on the positive impacts on yields and profits from adopting GM crop varieties, primarily in the United States. Even in the case of Roundup Ready soybean where some areas initially experienced slight reductions in yield, the lower herbicide costs and the time freed up have been more than sufficient compensation to lead to adoption.

[9] Because it makes little difference to the results being analysed here, we simply follow previous analysts in assuming that the productivity effects of genetic modification do not differ across crops or inputs (Nielsen and Anderson (2001), Anderson, Nielsen and Robinson (2002)). For studies that differentiate the degrees of factor/input saving, see van Meijl and van Tongeren (2002) and Huang et al. (2004).

[10] The EU moratorium is modelled because it is by far the biggest restrictor of products that may contain GMOs; and China is included in the Northeast Asia moratorium scenario because it has already imposed a GM-motivated import restriction, on US soybean in 2001 (since relaxed after intense US lobbying).

[11] The GTAP model does not disaggregate down to maize, soybean and canola but in the current GM adopting countries these three account for most of the coarse grain and oilseed production. For Australia and New Zealand those three crops are less dominant within the coarse grain and oilseed groups and so to achieve the same productivity increase in ANZ as in America would require further investment in adaptive biotech research on other coarse grains and oilseeds for ANZ conditions. The cost of such adaptive R&D is not included in what follows.

[12] Separate simulations of first Australia and then New Zealand adopting showed that each country is too small in global food markets to significantly affect the other's production, trade and welfare, so we only report their combined adoption in simulations 1c and 1d (and 2c, 2d and 3b, below).

[13] The large percentage export effect for New Zealand is very small in dollar terms because it is from a tiny base.

[14] The larger loss for China in this scenario is because Australia would be a major supplier of coarse grain imports by China if Northeast Asia were to cease buying from North America, but that trade ceases in the scenario in which ANZ adopts GM varieties.

[15] Australian consumers do this implicitly already through taxpayer matching of farmer R&D levies that jointly fund Australia's rural research and development corporations. Domestic food prices fall even though ANZ exports are a small fraction of world supplies because of the Armington specification in GTAP: there is a home market bias in consumption and each country's exports are an imperfect substitute for other countries' products in the eyes of foreign consumers.

[16] Also dampened by the EU moratorium has been investment in second-generation GM crop varieties that promise enhanced consumer attributes, such as vitamin-enrichment. New estimates suggest the extent of the welfare benefits from that development could well surpass those from the farm productivity growth provided by first-generation GM varieties (Anderson, Jackson and Nielsen 2004).

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