Transgenic crops have become a significant proportion of the world’s broadacre crop output since the commercialisation of herbicide tolerant soybeans in the United States in 1996. Australia has participated in this agricultural innovation with commercial plantings of transgenic cotton, but has delayed the commercialisation of other transgenic broadacre food and feed crops.

This article addresses economic aspects of the decision to delay the commercialisation of transgenic canola in Australia; the Office of the Gene Technology Regulator addresses health and environmental issues associated with growing transgenic organisms.

Australia’s canola producers suffer an economic loss as a consequence of the current state and territory moratoriums on commercialising transgenic canola.

A continuance of the current moratoriums, and extension to other transgenic broadacre crops, is expected to result in a loss of gross national product of $3 billion, in net present value terms, over the next ten years.

The basis of the debate from an economic perspective is highlighted in the legislation of the states and territories. It can be summarised as a debate about the marketing implications for Australia of domestic producers adopting transgenic food and feed crops on the one hand, or producing only conventionally developed food and feed crops on the other hand.

Box 1 provides an explanation of the differences between transgenic and conventionally developed plants.

**Regulation of transgenic crops in Australia**

At the federal level, the Australian Government introduced the Gene Technology Act in 2000 and the Gene Technology Regulations in 2001, and has established the Office of the Gene Technology Regulator to make decisions under the Act. All activities involving the growing of transgenic crops in Australia are subject to regulation under this Act and Regulations.

State and territory governments also have legislation to complement the federal regulatory framework. In addition, state and territory governments have the capacity to determine quarantine regulations and regulate land use in their own jurisdictions. Australian states and territories, with the exception of Queensland and the Northern Territory, currently have legislation in place that allows the responsible minister to prohibit the planting of specific transgenic crops. The effect of this legislation is to apply a moratorium on the commercialisation of particular transgenic crops. An overview of the principal Australian legislation regulating the planting of transgenic crops is presented in table 1.

There has been considerable pressure on Australian governments to regulate biotechno-
## Current Australian transgenic crop moratoriums

<table>
<thead>
<tr>
<th>State/Special Region</th>
<th>Moratorium legislation</th>
<th>Moratorium provisions</th>
<th>Moratorium effective until</th>
</tr>
</thead>
</table>
| New South Wales      | Gene Technology (GM Crop Moratorium) Act 2003 | • Responsible minister may order:  
  – prohibition on cultivation of specified GM food plants, or classes of GM food plants  
  – exemptions from prohibition orders  
• Act expires 3 March 2006 | 2006 |
| Victoria             | Control of Genetically Modified Crops Act 2004 | • Responsible minister may order:  
  – prohibition on cultivation of specified GM plants in specified areas of Victoria  
  – permissible areas in which specified GM plants or classes of GM plants may be cultivated  
  – conditions that attach to cultivation prohibition or permission orders  
  – exemptions from prohibition orders  
• Act includes an order prohibiting the cultivation of GM canola in Victoria until 29 February 2008 | 2008 |
| Western Australia    | Genetically Modified Crops Free Areas Act 2003 | • The Act and associated regulations provide for:  
  – the state, or areas thereof, to be declared a prohibited area for the cultivation of GM crops (declared so from 22 March 2004)  
  – the responsible minister to issue exemptions from conditions of the Act  
• The Act stipulates it must be reviewed in the sixth year following its commencement (commenced 24 December 2003) | 2009 |
| South Australia      | Genetically Modified Crops Management Act 2004 | • The Act and associated regulations provide for:  
  – the state to be declared a prohibited area for the cultivation of GM food crops (declared so from 29 April 2004)  
  – the responsible minister to permit limited and contained experiments and trials of GM food crops  
• The Act stipulates it must be reviewed within three years of commencement (by 29 April 2007) | 2007 |
| Tasmania             | Tasmanian Plant Quarantine Act 1997 | • In 2003, under this Act, the moratorium on the commercial release of GM crops (and animals) was extended to June 2008:  
  – the responsible minister may permit some dealings with GMOs under this Act — for example, for trials of certain GM crops |  |
|                      | Genetically Modified Organisms Control Act 2004 | • Allows for the state to be declared GMO free  
• Permits to be issued for persons to have dealings with specified GMOs | 2008 |
| Australian Capital Territory | Gene Technology (GM Crop Moratorium) Act 2004 | • Reviewed annually  
• Responsible minister may order:  
  – prohibition on cultivation of specific GM food plants  
  – exemption from prohibition of specified contained research and field trials approved by the Gene Technology Regulator  
• Act expires on a date to be fixed (not before 17 June 2006) | 2006 |
nology in agriculture, which has contributed to the existence of the current subnational policy stance. The main reason put forward for the current moratorium is to postpone the commercialisation of transgenic food crops in order to determine that the innovation will not jeopardise the marketability of Australian agricultural output. The New South Wales Gene Technology (GM Crop Moratorium) Act 2003, for example, specifically identifies the purpose of the Act as facilitating the identity preservation of transgenic and nontransgenic crops for marketing purpose, as does legislation in Victoria, Tasmania, South Australian and the Australian Capital Territory.

Box 1: Conventional and transgenic plant breeding

Human agricultural development endeavors have very often revolved around plant and animal breeding. At its most basic, an agricultural breeding program is a variation on natural selection. In natural selection, the most successful plants or animals of a species tend to dominate and thus the species evolves to do the best it can in the environment in which it lives.

Human intervention in the process of natural selection is generally intended to influence the dominance of particular characteristics in a species or subspecies. Plant breeders manipulate the genetic makeup of plants with the intention of influencing plant evolution in a direction that suits the needs of humans. In plant breeding, a number of techniques have been developed to facilitate the dominance of desirable plant characteristics. These can be generally classified as conventional or transgenic (genetic modification) techniques.

Conventional breeding
So-called conventional plant breeding generally utilises the plants sexual reproduction mechanism to manipulate the genetics of a plant variety. This type of plant breeding follows the framework of the Laws of Inheritance identified by Gregor Mendel in the mid-1800s.

Plant sexual reproduction usually involves combining two sets of around 25 000 genes. Gene governed traits that differ between the parents reassociate freely to produce a new plant with a new genetic profile. The new traits may be useful or useless, safe or harmful. The recombination of genes that gives rise to new traits presents as a breeding instrument that has been exploited by humans.

Conventional breeding techniques include:
- Human selection — selecting seed from plants expressing the most desirable characteristics, for planting the following year.
- Hybridisation — intervening in the reproduction process to cause cross fertilisation of specific plant lines. This includes generating ‘F1 hybrids’ by crossing two predetermined parental lines to achieve ‘hybrid vigor’ in the first generation progeny; and incorporating new genetic material by cross fertilisation with pollen from unrelated or distantly related plants. Triticale, a cross between wheat and cereal rye, is one example of the use of this technique. It was originally developed in the 19th century.
- Induced mutation or ‘mutagenesis’ — exposing seed to specific radiation or chemical agents in order to facilitate mutations in the hope that the mutation will be useful.
- DNA marker selection — using DNA examination techniques to select plants for breeding, according to whether they possess a particular piece of DNA.

Transgenic breeding
Transgenic or genetic modification of plants generally refers to the incorporation into plant cells of a specific piece of DNA from a foreign source, in order to confer a specific trait on the host plant. The main difference between transgenic breeding and conventional breeding, is that transgenic breeding does not rely on sexual reproduction, with its associated recombining of large numbers of genes.

Current transgenic breeding techniques allow a specific gene to be inserted into plant DNA at a specific point, permitting a precise analysis of the effect of the gene transfer on a range of genetically coded plant characteristics; and avoiding the diversity of effects of conventional breeding gene recombining.

Transgenic crops currently grown in Australia

As a consequence of the moratoriums, Australia has no commercial plantings of transgenic crops principally grown for food or feed. The only commercial broadacre transgenic crop in Australia is cotton; transgenic carnations are also produced.

Transgenic cotton

Transgenic cotton has been popular with farmers, despite regulations restricting the level of adoption of the technology in cotton production. Between 1996 and 2003, the transgenic proportion of total cotton plantings was regulated to remain below 30 per cent of plantings on each farm. This approach was intended to prolong the effectiveness of the insect resistant transgenes available in that period. The predominance of nontransgenic cotton reduced the evolutionary pressure for the target insects to develop resistance to the insecticidal characteristics of the transgenic cotton plants.

The introduction of a new transgenic variety for the 2003-04 growing season coincided with a change in regulation to permit up to 40 per cent of each farm’s cotton plantings to be transgenic varieties if certain conditions were met; and in 2004-05, as a result of the withdrawal from planting of the first generation transgenic cotton varieties, the cap on the transgenic proportion of cotton crops has been removed.

Cotton Australia report that more than 70 per cent of the cotton planted in Australia in 2004-05 was transgenic, with around 95 per cent of cotton farms growing transgenic cotton. This is a high adoption rate for this technology, comparable to the high adoption rates for transgenic crops in north and south America, and in China. This level of adoption of transgenic cotton in Australia shows that Australian farmers, when permitted, are likely to adopt transgenic varieties where net economic benefits exist.

Adoption of transgenic crops (in addition to cotton) has the potential to provide significant environmental benefits, similar to those outlined in box 2.

Transgenic crops globally

In contrast to Australia’s moratorium on commercialising transgenic food and feed crops, transgenic food and feed crops have been, and continue to be, adopted by agricultural producers in many countries. Details of the scale of transgenic cropping in the main transgenic crop growing countries are provided in table 2. Generally, countries that have been producing commercial quantities of transgenic crops since the 1990s have a relatively high level of farmer adoption of the technology.

In countries that have been producing commercial transgenic crops for more than five years, oilseeds and cotton crops tend to be mainly of transgenic varieties. The adoption rates for transgenic maize are lower, reflecting the generally lower incidence of producer benefit from that crop.

Globally, the main transgenic crops are maize, oilseeds and cotton. According to James (2004), in 2004, 56 per cent of global soybean plantings, 28 per cent of global cotton plantings, 19 per cent of global canola plantings and 14 per cent of global maize plantings were transgenic varieties. In 2004, around 6 per cent of world arable land was planted to transgenic crops, a significant global rate of takeup of these crops in the nine years since the commercialisation of transgenic broadacre crops.

In the future

The future for transgenic crops seems assured. Current commercial experience with transgenic crops with input trait modifications indicates that plantings of transgenic oilseeds, cotton and maize will continue to expand. Brazil produced 27 per cent of global soybean production in 2003-04 (ERS 2005) and appears poised to push the transgenic proportion of global soybean production close to 70 per cent. India produced 15 per cent of world cotton in 2003-04 (ERS 2005) and is gradually increasing the proportion of transgenic plants in the cotton crop. Transgenic maize is well established in north America and continues to be adopted in developing countries such as the Philippines and South Africa.
Transgenic crops not yet commercialised also have strong prospects for the future of transgenic food crops. China is developing a wide range of transgenic food crops, and is ‘on the threshold of commercialising transgenic rice’ (Huang et al. 2005, p. 688). The large scale commercialisation of a major food crop, such as rice, is likely to result in an acceleration of the development and adoption of transgenic food crops — particularly if the commercialisation takes place in a country with a government funded biotechnology research and development capacity, such as China, India or Viet Nam (Brookes and Barfoot 2003).

Box 2: Benefits of transgenic cotton in Australia

Australian cotton growers have a high rate of adoption of transgenic cotton varieties. The apparent reasons for the high rate of adoption include both economic and environmental motivations.

Economic benefits
Transgenic, insect resistant (IR) cotton has demonstrated an economic benefit to growers by virtue of generally requiring less insecticide to achieve a successful crop outcome, reducing expenditure on insecticidal chemicals. Not only is the volume of insecticide lower for transgenic IR cotton, but fewer applications are necessary, thus further reducing the costs of applying insecticides.

Sample enterprise budgets from the New South Wales Department of Primary Industries indicate that transgenic IR cotton crops in the northern zone of New South Wales typically apply around 60 per cent less insecticide in half the number of applications required for conventional cotton crops. According to the sample budgets, farmers could expect to lower their insecticide and application costs by around 85 per cent by using Bollgard II® cotton, resulting in a reduction in total variable costs of production of around 2 per cent. Assuming the producer prices for transgenic and conventional cotton are the same, growers of transgenic cotton could expect to improve the profitability of their businesses.

Environmental benefits
In addition to the economic benefits accruing to farmers from the introduction of the latest generation of transgenic cotton, environmental benefits are also evident. The environmental benefits relate to the reduced use of pesticides, and changes to insect management regimes following the introduction of Bollgard II® cotton. In Australia, cotton growers have reduced pesticide use to around 40 per cent of the volume previously used on conventional cotton crops. Compounding the environmental benefits of a general decrease in insecticide use is the reduction in use of some of the more toxic and persistent insecticides, such as endosulfan. Using transgenic IR cotton in an integrated pest management approach has reportedly resulted in a reduction in endosulfan use of around 90 per cent in Australian cotton production.

In addition to reduced pesticide use, weed management systems involving herbicide tolerant transgenic cotton have been shown to be less damaging to the environment than conventional cotton production systems. The environmental benefit is derived from less toxic broad spectrum herbicides that break down rapidly on contact with soil, being used in place of more toxic and environmentally persistent herbicides. Use of broad spectrum nonpersistent herbicides also facilitates the adoption of reduced tillage agricultural practices, a factor in reducing soil degradation on farms.

Health benefits
The potential environmental and health benefits of reduced pesticide use as a result of adoption of transgenic crops is illustrated well by the Chinese experience with transgenic cotton. In China during the years 1992–96, on average each year 54,000 farmers and farm workers were poisoned as a result of pesticide use, with a resultant 490 deaths. The cotton sector, a major user of pesticides, contributed significantly to this tally.

Surveys in China in the period 1999–2001 revealed that use of IR transgenic cotton (Bt cotton) resulted in a decline in the quantity of pesticides used, and a decline in the number of farmers and farm workers reporting cases of pesticide poisoning. The decline in quantity of pesticides used included declines of more than 50 per cent in the most toxic pesticides used on cotton.

Sources: Crossan and Kennedy (2004); Hossain et al. (2004); Larkin (2005); NSW DPI (2004a).
Global commercialisation of transgenic crops potentially has impacts for Australia in overseas export markets and in the Australian domestic market. The potential impacts differ depending on whether Australia produces transgenic crops or not, and on the degree of transgenic crop production in competitor nations.

In international markets, transgenic crops with productivity enhancing input traits, such as those being rapidly adopted globally, can be expected to exert downward pressure on the prices for those crops. Given that Australian producers are price takers in these competitive world markets, preventing the commercialisation of transgenic crops in Australia means that Australian producers receive a reduced benefit from their crop. This will manifest itself as reduced market share and reduced profitability for Australian producers, compared with the outcome if Australian producers were permitted to grow transgenic crops commercially.

Trade data indicate that Australian producers currently compete in a number of export markets in which transgenic crops have a significant market share. Australian producers also participate in a number of markets in which transgenic crops have the potential to be significant competitors for conventionally bred crops in the future.

### Main transgenic crop producers in 2004

<table>
<thead>
<tr>
<th>Commercialised transgenic broadacre crops</th>
<th>Total transgenic crops</th>
<th>Commodities</th>
<th>Estimated share of crop that is transgenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>1996</td>
<td>47.6</td>
<td>Soybeans, maize, cotton, canola</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Argentina</td>
<td>1996</td>
<td>16.2</td>
<td>Soybeans, maize</td>
</tr>
<tr>
<td>Canada</td>
<td>1996</td>
<td>5.4</td>
<td>Canola, maize, soybeans</td>
</tr>
<tr>
<td>Brazil</td>
<td>2003</td>
<td>5.0</td>
<td>Soybeans</td>
</tr>
<tr>
<td>China</td>
<td>1997</td>
<td>3.7</td>
<td>Cotton</td>
</tr>
<tr>
<td>Paraguay a</td>
<td>2004</td>
<td>1.2</td>
<td>Soybeans</td>
</tr>
<tr>
<td>India</td>
<td>2002</td>
<td>0.5</td>
<td>Cotton</td>
</tr>
<tr>
<td>South Africa</td>
<td>1998</td>
<td>0.5</td>
<td>Maize, soybeans, cotton</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uruguay</td>
<td>2001</td>
<td>0.3</td>
<td>Soybeans, maize</td>
</tr>
<tr>
<td>Australia b</td>
<td>1996</td>
<td>0.25</td>
<td>Cotton</td>
</tr>
<tr>
<td>Romania a</td>
<td>1999</td>
<td>0.1</td>
<td>Soybeans</td>
</tr>
<tr>
<td>Mexico a</td>
<td>1996</td>
<td>0.75</td>
<td>Maize, cotton</td>
</tr>
<tr>
<td>Spain</td>
<td>1998</td>
<td>0.58</td>
<td>Maize</td>
</tr>
<tr>
<td>Philippines a</td>
<td>2003</td>
<td>0.52</td>
<td>Maize</td>
</tr>
</tbody>
</table>


Canola

Japan, China, Pakistan and Bangladesh were the main destinations for Australian canola seed in the years 2000–04 (ABARE 2004). Over that period, 41 per cent of the export returns to Australian canola seed where derived from the Japanese market, 21 per cent from China, 17 per cent from Pakistan and 10 per cent from Bangladesh — that is, 88 per cent from these four Asian markets (UN 2005).

These four markets for Australian canola seed are dominated by Australian and Canadian canola, with European producers playing a minor role. For example, Australian and Canadian producers met 95–100 per cent of Japanese import demand in the period 2000–04; in the Chinese market, Canada supplied 68 per cent and Australia 24 per cent of import demand.

Canadian producers of transgenic canola have not lost market share in their main export markets for canola seed, and they appear to have a production cost advantage over Australian producers by virtue of lower costs in their weed suppression regimes. Lower costs of production in Canada are a potential threat to the continued viability of Australian exports of canola seed, but there is no apparent threat to Australian canola seed exports from the commercialisation of transgenic canola in Australia (Lloyd 2003).

Given the lack of evidence of a price premium for Australian nontransgenic canola (Foster 2003), Australian canola seed producers receive no economic benefit from forgoing the potential productivity gains from growing a suitable transgenic canola variety. In fact, they suffer an economic loss as a consequence of the current moratoriums.

Cereal grains

China is potentially a growth market for a number of Australian broadacre crops. Two factors are likely to converge in the near future, revealing China as a large market for transgenic crops. China has developed a large state supported agricultural biotechnology research and development capacity and is likely to commercialise transgenic food grains in the near future (Huang et al. 2002); and China’s growing affluence and changing dietary preferences are likely to result in increased demand for malting barley, feed grains and high quality food grains (Roberts and Andrews 2005). These factors point to a potential opportunity to increase Australian grain exports, including transgenic grains, into a very large and expanding market.

Research and development impacts

Agricultural innovations such as transgenic crops have the potential to provide benefits to producers and consumers. While consumers will tend to benefit from lower prices for agricultural products in the long run, the level of benefit flowing to producers depends partly on whether they are early adopters of innovation or not.

Early adopters tend to accrue benefits from increased yields or lower costs compared with the majority, which translates into improved profitability. Late adopters are essentially catching up to the majority. In a competitive commodity market, late adopters reduce their costs, for example, after the reduced costs of the majority have lowered the market price, while early adopters reduce their costs under the existing higher market price.

To be well positioned to take advantage of opportunities such as those mentioned above, Australia needs to maintain a significant level of research and development in the agricultural biotechnology field. In order to maintain or increase investment, private companies and government research facilities require a reasonable level of certainty about their future opportunities to generate an economic return on their investment.

The state bans on commercialising transgenic canola are contributing to uncertainty in Australia’s biotechnology research and development effort — Fitzgerald (2004) reports that Monsanto has withdrawn from developing transgenic canola in Australia as a result of regulatory restrictions and the moratorium on producing transgenic canola.

A reduction in research and development capacity in this field has the potential to impact negatively on future Australia grain trade. The policy stance of the Australian states appears to
be jeopardising the future benefits from transgenic crop developments.

Quantifying the impact of the moratoriums

Since 2001, a number of studies have attempted to quantify the economic impacts of transgenic crop commercialisation (Nelson et al. 2001; Stone, Matysek and Dolling 2002; Abdalla et al. 2003; Anderson and Jackson 2005).

While these studies have varied in terms of the assumptions used in their economic modeling, they tend to agree in their broad conclusions: generally, given the current level of transgenic broadacre cropping, and under a range of possible future scenarios, economic benefits would tend to accrue to Australia from the commercialisation of transgenic crops in Australia, compared with not commercialising transgenic crops.

In order to quantify the welfare implications of the debate concerning whether Australia should commercialise transgenic food and feed crops, and to update earlier modeling results using current estimates of productivity gains, current levels and rates of adoption, and current indicators of likely future developments, this study included an economic modeling exercise as set out below.

The potential impacts on Australia of adopting transgenic crops were estimated using ABARE’s global trade and environment model (GTEM). GTEM is a dynamic computable global general equilibrium model of the world economy that provides a suitable framework for analysing domestic and international policy changes, as it takes into account the interactions between sectors within a country as well as the linkages between countries brought about by trade and investment.

Two scenarios simulated

- Australian states prohibit commercial plantings of transgenic grain and oilseed crops, while there is further transgenic crop adoption in other countries.
- Australia adopts transgenic varieties of wheat, barley and canola.

In these scenarios, the adoption of a transgenic crop is assumed to result in a productivity improvement for the sector adopting the new technology — that is, for a given level of inputs, output expands by the productivity improvement percentage.

Background information on the assumed productivity improvements is provided in box 3. It is assumed that all productivity improvements are phased in over the five years from 2006 to 2010. Additionally, no trade barriers relating to transgenic adoption are considered in the simulation as it is assumed that there are still sufficient nontransgenic producers, such that there is no nontransgenic premium in world markets. Likewise, no adverse impact on domestic consumers from the adoption of transgenic crops is considered. Finally, any identity preservation and segregation costs are not explicitly modeled — these are the subject of ongoing research by ABARE and others.

Box 3: Assumed productivity gains in selected crops

In order to quantify the welfare implications of Australia either commercialising or not commercialising the transgenic food and feed crops involved, productivity improvements for maize, canola, wheat and barley were modeled. These crops were chosen as they are important to Australian agriculture and transgenic varieties of these commodities have been developed in Australia and elsewhere.

The productivity gains in maize and canola are based on published results of field trials and/or commercial production experience in the relevant countries. There are no commercial plantings of transgenic barley or wheat — productivity gains assumed for these commodities are based on published estimates of productivity improvements from trials, and on estimates of gross margin changes resulting from changed herbicide application regimes as a result of transgenic varieties expressing tolerance to particular herbicides.

Sources: Foster (2003); James (2003); Johnson, Lin and Vocke (2005); NSW DPI (2004b).
The timeline used in the modeling has been chosen to demonstrate the near-future magnitude of the potential benefits of commercialising transgenic crops in Australia. Transgenic crops, including wheat and barley, continue to be developed and could potentially be commercialised in the near term, while commercially viable transgenic varieties of canola have already been developed for Australian conditions.

Results

In the first scenario, Australia does not adopt any transgenic crops. Meanwhile there is further transgenic adoption in other countries. The assumed productivity gains are:

- a 5 per cent productivity gain for wheat in the United States/Canada, Brazil, Argentina, China and India; and
- a 10 per cent productivity gain for maize in Brazil, India and China. (The United States/Canada, and Argentina are assumed to already be at their maximum level of adoption of transgenic maize.)

In the second scenario, in addition to the transgenic crop adoption modeled in the first scenario, some transgenic crop adoption is assumed for Australia. As in scenario one, transgenic crop adoptions are assumed to be phased in over the five years from 2006 to 2010. The assumed productivity gains for Australia are:

- a 5 per cent productivity gain for canola,
- a 5 per cent productivity gain for wheat and
- a 10 per cent productivity gain for barley.

The gross national product (GNP) difference between these two scenarios represents the difference in national economic welfare of Australia either adopting or not adopting transgenic grain and oilseed crops in the face of further global uptake of transgenic crop technology.

Results of the modeling indicate that Australia can derive substantial benefit from transgenic crop technologies. Productivity gains from commercialising transgenic varieties boost Australian production of wheat, barley and canola.

The model indicates that the benefits to Australia increase over time as the level of uptake of the technology increases, with the 2005 net present value (in 2004 Australian dollars) of the total benefits in the period 2006–15 being approximately $3 billion (table 3).

In the light of uncertainty over the productivity gains that would actually be realised from transgenic technology adoption, a sensitivity analysis was conducted. This analysis involved simulating the impacts of halving the assumed productivity gains from transgenic crop adoption, and simulating the impacts of doubling the assumed productivity gains.

The sensitivity analysis indicates that the net present value of Australian GNP growth would be between $1.5 billion and $5.8 billion. Even allowing for variation from the assumed productivity gains there are still significant potential gains to Australia from adopting transgenic grain and oilseed crops.

Concluding comments

Transgenic broadacre crops are proving their value to producers and consumers the world over. Levels of adoption are already high for transgenic maize, cotton and oilseeds. Developments in countries such as China, India and Brazil point to a continued expansion of transgenic crop plantings, with transgenic food grains likely to be commercialised in the near future.

In contrast to the increasing global adoption of transgenic crop technology, most Australian states and territories have legislated to prohibit the commercial production of transgenic canola.

There is no apparent economic justification for Australia to delay the commercialisation of transgenic canola. Australian canola seed

<table>
<thead>
<tr>
<th>Table 3: GNP gains for Australia from transgenic crop adoption</th>
<th>Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assumed productivity gains</td>
<td>$2,952</td>
</tr>
<tr>
<td>Sensitivity analysis</td>
<td></td>
</tr>
<tr>
<td>Productivity gains halved</td>
<td>$1,492</td>
</tr>
<tr>
<td>Productivity gains doubled</td>
<td>$5,770</td>
</tr>
</tbody>
</table>

*Net present value in 2005 of gains in gross national product to 2015.*
producers compete with transgenic canola seed in their main export markets. Those markets willingly accept transgenic canola. In the absence of a defined market and a price premium for nontransgenic canola, the moratoriums are generating an economic loss for Australia. Australian canola producers are prevented from sharing the economic benefits of transgenic canola that are being enjoyed by the other major supplier of Australia’s canola export markets, Canada.

Likely future developments in markets, in Asia in particular, and in transgenic crops will result in expanding opportunities for broadacre transgenic crops in Australia. There is evidence that the transgenic canola moratorium threatens Australia’s capacity to react to emerging opportunities in the field of crop development.

While the debate on the commercialisation of transgenic crops in Australia is yet to be concluded, ABARE modeling indicates that a failure to commercialise transgenic crops now and in the near future could, by 2015, cost Australians between $1.5 and $5.8 billion in forgone gross national product.

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