THE POTENTIAL IMPACTS OF GENETICALLY MODIFIED MAIZE ON THE SOUTH AFRICAN MAIZE TRADE [1]

REPORT TO THE MAIZE TRUST

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EXECUTIVE SUMMARY

The advent of the genetic modification of organisms, or biotechnology, has brought a rapid change to the world's agricultural production and trade. Whilst some countries have welcomed this new technology, others were decidedly against it. By 2006, GM crops were grown by 10,3 million farmers in 22 countries on 102 million hectares. Of the 10,3 million farmers, 90% were small-scale, resource poor ones from developing countries. Of the 102 million hectares of GM crops, 57% was soybeans, 25% was maize, 13% was cotton, and 5% was canola. In 2006, South African farmers had planted GM cultivars on 48,3% of the maize area, 75% of the soybean area, and 92% of the cotton area.

In the maize industry adoption of GM maize has been rapid. For example in the US adoption increased from 4% of area planted to 61% in 2006. In Argentina the area planted with GM maize increased from 5% of the area planted in 1999 to 67% in 2006. These two countries' together averaged 79.1% of world exports of maize for the period 2002/03 to 2006/07. In South Africa GM maize comprised 48,3% of the total area planted to maize in the 2006/07 production season. Adoption in South Africa was also rapid. For white maize adoption increased from around 3% in 2002/03 to just over 40% of total area planted, while yellow maize adoption increased from just under 20% in 2002/03 to just below 60% in 2006/07. The advent of the stacked events will undoubtedly encourage the further adoption of the technology, and when the drought tolerant events become available, the adoption could become virtually 100%.

To date, the international development of the various GM maize events has mainly targeted the achievement of herbicide tolerance (notably Roundup) and insect resistance (notably stalkborer) in maize cultivars in order to reduce the use of herbicides and pesticides and to decrease the cost of production. In South Africa, four maize events have been approved for general release in South Africa (i.e. importation, exportation, commercial planting, and use for food and feed), namely: MON810/Yieldguard (insect resistant, approved in 1997), NK603 (herbicide tolerant, approved in 2002), Bt11 (insect

resistant, approved in 2003) and NK603 (stacked herbicide tolerant and insect resistant, approved in 2007). Various other events have been approved for commodity clearance (i.e. for importation but not for domestic production), namely MON810 x NK603, MON810 x GA21, and TC1507 (all stacked genes for insect resistance and herbicide tolerance), GA21 and T25 (both herbicide tolerant), and Bt176 (insect resistant).

The developments in the GM environment mentioned above also had yield increasing effects in the production of maize. Various researchers have found/assumed yield advantages from 7,5% to 11,3% over conventional maize, whilst GM companies interviewed indicated that a yield advantage of 10% would probably be a best generalised approximation. Other research have shown that GM technology has at farm level resulted in significant improvements in productivity and profitability. The farm income benefits from GM maize for the period 1996 to 2005 was estimated at US $1957 million in the USA, $159 million in Argentina, and $59 million in South Africa. More specifically, research has shows that in the 2000/01 and 2001/02 years in South Africa, Bt maize had a 11,03% and 10,60% yield advantages over conventional varieties under irrigation and dryland conditions respectively. In addition, it enabled significant savings on pesticides, it did not carry any commodity price penalties, but had higher seed cost. In balance, the net benefit of Bt maize for commercial farmers was on average US $24 per hectare on dryland conditions in the North West Province, US $47 per hectare dryland in Mpumalanga, US $85 per hectare under irrigation in Mpumalanga, and US $149 per hectare under irrigation in the Northern Cape. This research also found that Bt maize had significant yield and profit advantages for small-scale farmers in various farming areas. South African farmers currently do not receive large premiums for non-GM maize on the market side. Under dryland conditions, the premiums currently vary between R nil and R40 per ton; under irrigation the premiums are around R75 per ton due to higher rates of herbicide and insecticide applications and the high cost of aerial applications of chemicals.

The escalation in the production of GM crops due to the observed advantages they have rapidly increased the biosafety concerns and this lead to several international agreements and various domestic regulations by countries on genetic modified organisms (GMO's) pertaining to the production, consumption and importation of GM derived food and feed products. Unlike conventional (non-GM) products, GM products are subject to specific import procedures or import bans in many countries, labelling requirements in an increasing number of countries, and even traceability requirements in some countries. The Sub-Saharan African countries, which are the main export destinations of South African maize, do currently not allow the importation or domestic production of GM maize. Most of the countries are however in process of developing their GM regimes and will probably become more GM friendly in the near future. Most of them allow the importation of GM maize in milled form, which means that their GM concerns are environmental rather than health or consumer resistance, and as they develop their GM legislation and regulations they will start to approve GM events for general release. The notable exception in this regard is Zambia that seems to have some market advantage objectives in its GM approach. South African biotechnology policy is formulated under the Genetically Modified Organisms (GMO) Act of 1997 as modified in 2006 by the Genetically Modified Organisms Amendment (Act Number 23 of 2006). South Africa's GM legislation and regulations are largely cautious but not restrictive. However, whilst these agreements and regulations are aimed at the biosafety aspects of the GMO's, they can have a distinct impact on the international trade in GM products.

One also needs to take cognisance of consumer concerns since it is their actual and perceived concerns that to a large degree drive the different regulations and legislation. In South Africa, there is no notable resistance to GM maize based food products and the labelling regulations are not restrictive as only such products that are "significantly different" from the non-GM food products have to be labelled as such. Only one of the major food retailing groups insists on labelling GM food products, but these labels are not obtrusive and has to date not had any notable effect on the consumption of the products. The industrial processors of maize do demand non-GM maize, but this demand is based on concerns that the domestic food consumers may at some stage be incited to reject GM based foods and will most likely be relaxed as the processors are persuaded that the majority of the consumers have in fact accepted GM food products as safe (e.g. as in the USA). This demand also seems to be premium sensitive and may be amended as premiums for non-GM maize increase.

In the context of the above, it should be noted that:

(i) The main origins of South African maize are from countries where adoption of GM maize is rapid and expected to increase; and

(ii) South Africa's main trading partners in maize have differing stances on GMO's, and many of them may well change their current stances and regulations as the international conventions and agreements on GMO's further evolve.

Therefore, the evolution of the GM regimes will undoubtedly affect the international demand for South African maize, as well as the supply to South Africa, and thus the future profitability of maize production in South Africa. The overall objective of the research was therefore to estimate the potential impacts of GM maize on the South African maize trade. In order to quantify such potential impact a Computable General Equilibrium model, namely the GTAP model, was used.

In is important that cognisance is taken that various researchers that used the GTAP model to study the impact of GMO's on trade achieved disappointing results because the scenarios they generated were based on assumptions that were too general. A review of the various studies revealed that apart from some generalisations, no relevant conclusions could be drawn from them applicable to South Africa. Therefore, to obtain realistic information for this study, various role-players in the South African maize industry were interviewed and followed by comprehensive desktop studies on the domestic and international maize trade situation and recent developments therein to finally derive the most accurate and probable assumption from a South African point of view. These assumptions were used to construct different scenarios that were modelled.

The results from the GTAP model shows that policy measures that will restrict the country's access to new GM maize events will disadvantage both the domestic producers and consumers of maize. The consumers will suffer a decrease in total welfare whilst the producers will be disadvantaged in terms of imported competition. The model shows that, more specifically:

(i) The continued approval and domestic adoption of new GM maize events will be in the best interest of the country; the world's continued adoption of GM technology will depress world prices and increase import competition for South African maize producers, and their best remedy is to have access to the same technology;

(ii) If the domestic consumers would totally reject GM maize based food products, the effect on both the country and the maize industry will not be very significant as the resultant loss in technical efficiency on the production side of the economy will be compensated for by much lower costs to segregate and identity preserve (SIP costs) non-GM maize; the farmers no longer plant GM white maize but will continue to plant GM yellow maize whilst the feed industry does not require non-GM maize;

(iii) If the domestic consumers would, however, fully accept GM maize based foods and beer, the impact on the country as a whole and on the maize industry will be significantly beneficial, especially as the total SIP cost in the economy will virtually disappear and the domestic price and imports of maize will decrease; and

(iv) It is important for the South African maize industry to maintain and increase maize exports to the SADC countries; if this demand should fall away, the domestic production of maize could drop by more than 7%.

Resulting from the study, the following recommendations are pertinent:

(i) Because the world swing to GM maize will inherently depress the world price of maize, the South African GM authorities should continue to approve new GM maize events for general release, and commodity clearance before general release should be the exception rather than the rule;

(ii) The South African maize industry should make concerted efforts to persuade the domestic consumers of the food safety of GM maize based foods;

(iii) The South African authorities and maize industry should assist the other SADC member countries to develop and adopt proper GM policies and regulations;

(iv) The South African GM authorities should compel all maize imports to be retested for the presence of GMO's on arrival before permitting the cargoes to be discharged; and, finally,

(v) It is recommended that trade flows between countries should be scrutinised in detail to check for the correctness of actual flows. This would entail a proper evaluation of the base data of the GTAP model specific to countries playing a relatively smaller role in the international trade of agricultural products.

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INTRODUCTION

1.1 Background

The advent of the genetic modification of organisms, or biotechnology, has brought a rapid change to the world's agricultural production and trade. The ability to transfer genes between unrelated species provided a mechanism for the creation of various benefits but also raised concerns about the health and environmental safety of the new, genetically modified, species.

According to Kennett (2003), genetically modified (GM) crops were first commercially grown in the early 1990's and the acceptance of the technology has escalated to the extent that by 2002, around 46% of the world's soybean production, 20% of the world's cotton production, 11% of the world's rapeseed production and 7% of the world's maize production were produced from GM crops. Whilst some countries have welcomed this new technology, others were decidedly against it. By 2006, according to James (2006), GM crops were grown by 10,3 million farmers in 22 countries on 102 million hectares. Of the 10,3 million farmers, 90% were small-scale, resource-poor farmers. Of the 102 million hectares of GM crops, 57% was soybeans, 25% was maize, 13% was cotton, and 5% was canola. Developing countries planted 40% of the total GM area. The major GM trait is herbicide tolerance (68% of the total area planted), followed by insect resistance (19%), and stacked genes of the two traits (13%).

The escalation in the production of GM crops rapidly increased the biosafety concerns and this lead to several international agreements and various domestic regulations by countries on genetic modified organisms (GMO's). However, whilst these agreements and regulations are aimed at the biosafety aspects of the GMO's, they can have a distinct impact on the international trade in GM products. In this regard, it is important to note that the regulators in various countries have different stances on these issues. For instance, whilst the policy makers in the USA are generally in favour of GMO's, those in western and northern Europe are generally more cautious and have adopted much more stringent regulations on the production, consumption and importation thereof.

In the international arena, the main agreements that have been structured to, amongst others, regulate trade in GMO's are the Cartegena Protocol on Biosafety (to provide specific procedures for the export and import of live modified organisms), the Codex Alimentarius (to recommend minimum standards on food safety that all countries should follow), and specific agreements under the ambit of the World Trade Organisation (namely the Agreement on the Application of Sanitary and Phytosanitary Measures, and the Agreement on Technical Barriers to Trade). The practical implementation of these agreements is however still in a process of evolvement and still leaves many loopholes for possible trade abuses.

The world is clearly still responding to the advent of GMO's, with large differences between the proponents and opponents thereof. The disparate approaches have increasingly moved from the technical/biosafety level to trade issues.

1.2 Motivation

South Africa's main trading partners in maize have differing stances on GMO's, and many of them may well change their current stances and regulations as the international conventions and agreements on GMO's further evolve. Over 70 per cent of South Africa's maize exports go to Africa. The Southern African Development Community (SADC) has established an Advisory Committee on Biotechnology and Biosafety to provide expert guidance on policy and legislation development. Specific procedures already exist, including a South African procedure for handling in-transit consignments of grains destined for neighbouring countries. The evolution of the GM regimes will undoubtedly affect the international demand for South African maize and thus the future profitability of maize production in South Africa. Over and above this regulatory framework, consumer attitudes to GM foods are also changing. According to Jooste et al

(2004), the customer awareness of GM products in South Africa is still in an embryonic stage. More than half of the consumers surveyed in South Africa do not know what a GMO is, whilst 26 per cent are very much aware and slightly in favour thereof. The remaining 19 per cent of consumers are also aware of GMO's, but slightly opposed to them. In contrast, the consumers in western and northern Europe are very much aware thereof. According to Kennett (2003), 61% of the British consumers and 76% of the French consumers had indicated that they did not want to eat GM foods, and in Germany, nearly four-fifths of the population had said they would be unlikely to buy GM foods.

In 2006, South African farmers had planted GM cultivars on 46% of the maize area, 75% of the soybean area, and 92% of the cotton area. According to James (2006), South Africa is estimated to have enhanced farm income from GM crops by US $76 million in the period 1998 to 2005. GM crops are clearly firmly established, and the question is whether the farm level advantages thereof will not in future be offset by developments in the domestic and international GMO environment. More specifically, the relevant key questions are:

- What exactly are the current net advantages in the domestic production of GM maize?
- What exactly are the expected developments in the GM regimes of the more important buyers of South African maize (e.g. Japan, Southern African countries, Western Europe)?
- To what extent could the current non-awareness of the South African consumers regarding GM foods be expected to change? Do they have sufficient scientific information to base their decisions on? What can/should the South African maize producers do to inform the domestic consumers?
- Is South Africa's current GMO regime the optimum one? Should it in any way be amended to capture maximum advantages in the future?
- To what extent would/should the current growth rate in the cultivation of GM maize in South Africa be maintained?

- To what extent can the South African maize industry continue to segregate GM and non-GM maize under informal arrangements or a formal Identity Preservation System? And at what cost?
- What exactly should South Africa's stances be in the international forums where GM issues are debated?
- Should the South African government and the maize industry encourage SADC members to harmonise their GM regimes?

Despite the fact that the answers to these questions will provide important guidelines for South African policy makers, the issues have not yet been properly researched.. This means that to date, trade policy scientists have not been able to provide convincing inputs to policy makers on the issue of GM trade by South Africa, with the result that current policies might not necessarily be to the best benefit of the maize industry or the country as a whole.

1.3 Objectives

The overall objective of the study was to calculate and quantify the potential impacts of GM maize on the South African maize trade in order to provide a scientific input to South African policy makers on GM maize related regulations in the domestic market, as well as on their stances in the international conventions. Within this overall objective, the study also addressed the following objectives:

(a) To describe the inherent conflict between maize industry role players like the producers, dry millers, wet millers, feed manufacturers, maize traders, seed producers and the food and chemical industries;

(b) to define the GM maize varieties approved for commercial release in South Africa, as well as those varieties that are still in the pipeline;

(c) to list the national regulatory regime for GM maize in South Africa, as well as regimes established between buyers and sellers in the commercial arena;

(d) to draw up a national inventory of the practical realities through the whole maize production and marketing chain with regards to opportunities/restrictions with GM maize, additional benefits and costs related to GM maize, premiums for non-GM maize in the various markets, and any price penalties for GM maize;

(e) to describe the capacity for, cost of, and practical problems related to the identity preservation of non-GM maize per sub-region in South Africa;

(f) to obtain up-to-date information on the latest developments in the international GMO arenas, including the arbitration cases in the WTO, and to interpret the implications thereof for the South African maize industry;

(g) to quantify the import/export markets for South African maize and to describe the GM policies and regulations in each one; and

(h) using the above as inputs, to model the potential impact of GM maize production and regulations on the South African trade in maize.

1.4 Methodology

The most suitable model for the calculation of the GM effects is the Global Trade Analysis Project (GTAP) model. This model was developed by the Purdue University in collaboration with the Centre of Political Studies at the Monash University in Victoria, Australia. It is a comparative static model that allows for the determination of a base period scenario which is then altered sequentially by the application of “shocks” of appropriate magnitudes consistent with economic theory, practical realities, and possible negotiation positions. A particular attraction of this model is that it comes with both an extensive database and analytical tools for the processing and interpretation of the data and results. The database covers 87 countries/regions and 57 sectors of economic activity.

However, to draw meaningful conclusions from the application of the model, it is important that the scenarios that are tested in the model are based on assumptions which are consistent with practical realty. Various researchers that used the GTAP model to study the impact of GMO's on trade achieved disappointing results because the scenarios they generated were based on assumptions that were too general.[2] Jooste *et al.* (2004) had reviewed various such studies and concluded that, apart from some generalisations, no relevant conclusions could be drawn from them applicable to South Africa. Therefore, to obtain realistic information for this study, various role-players in the South African maize industry were interviewed and this was followed by comprehensive desktop studies on the domestic and international maize trade situation and recent developments therein. The results were systemised and discussed with role players in the South African maize industry for accuracy and relevance.

[2] See for instance Stone *et al.* (2002), Anderson and Jackson (2004a), Nielson and Anderson (2000a), and Huang *et al.* (2002).

SECTION 2
THE WORLD GM MAIZE SITUATION

2.1 The world food dilemma

The world finds itself increasingly in a dilemma to optimally balance the production and consumption of food in general and specifically also with regards to the production and consumption of maize. On the one hand the world is increasingly hard pressed to feed its population and therefore it has to increase the production of food. On the other hand the world's population is increasingly concerned about food health and safety issues and some of these concerns may be abused to form barriers to trade.

On average, over the past 5 years, the world consumed 2,3% more rice than what it produced, 2,4% more wheat, and 1,8% more maize (FAS, 2007). Consumption seems to be gradually outstripping production, which has lead to a sharp decrease in the world ending stocks (Table 2.1), and this was despite above average production years in the major producing countries for most of this period. This means that the world can now ill afford below average production years. More than three centuries ago, the economists, Malthus, Ricardo and Mill, postulated that the world will run out of food in the foreseeable future as the population grows at a faster rate than does the production of food (Gide and Rist, 1964). Today the problem of sufficient food at affordable prices is still actual, and scientists are continuously challenged to find new ways to improve the productive capacity of agriculture. In this regard, the genetic modification of plants and animals has now become an important tool.

On the production side, the GM technology is clearly rapidly being adopted. On the demand side, however, the insertion of foreign genes into plants has raised various questions on the human, animal and environmental safety of the "new" species. Many countries have adopted stringent regulations on the production, consumption and importation of GM derived food and feed products. Unlike conventional (non-GM) products, GM products are subject to specific import procedures or import bans in many countries, labelling requirements in an increasing number of countries, and even traceability requirements in some countries. These regulations are such that they could be abused as non-tariff trade barriers to protect domestic producers against imported competition.

Table 2.1: The world production, consumption and ending stocks of grains for the past 10 marketing years

Marketing years	Maize			Rice (milled)			Wheat		
	Produc-tion	Consump-tion	Stocks	Produc-tion	Consump-tion	Stocks	Produc-tion	Consump-tion	Stocks
	Million tons								
1997/98	574	574	166	387	377	128	610	577	197
1998/99	606	581	190	395	388	134	590	578	208
1999/00	608	600	193	409	397	144	586	581	209
2000/01	591	608	174	399	393	147	582	583	206
2001/02	600	321	150	399	412	133	581	586	202
2002/03	603	327	126	378	405	104	568	603	166
2003/04	627	648	104	392	411	82	555	581	133
2004/05	715	687	131	401	405	75	628	608	151
2005/06	696	702	123	418	412	77	623	619	149
2006/07	701	721	101	416	417	76	593	619	124
Source: FAS (2007)									

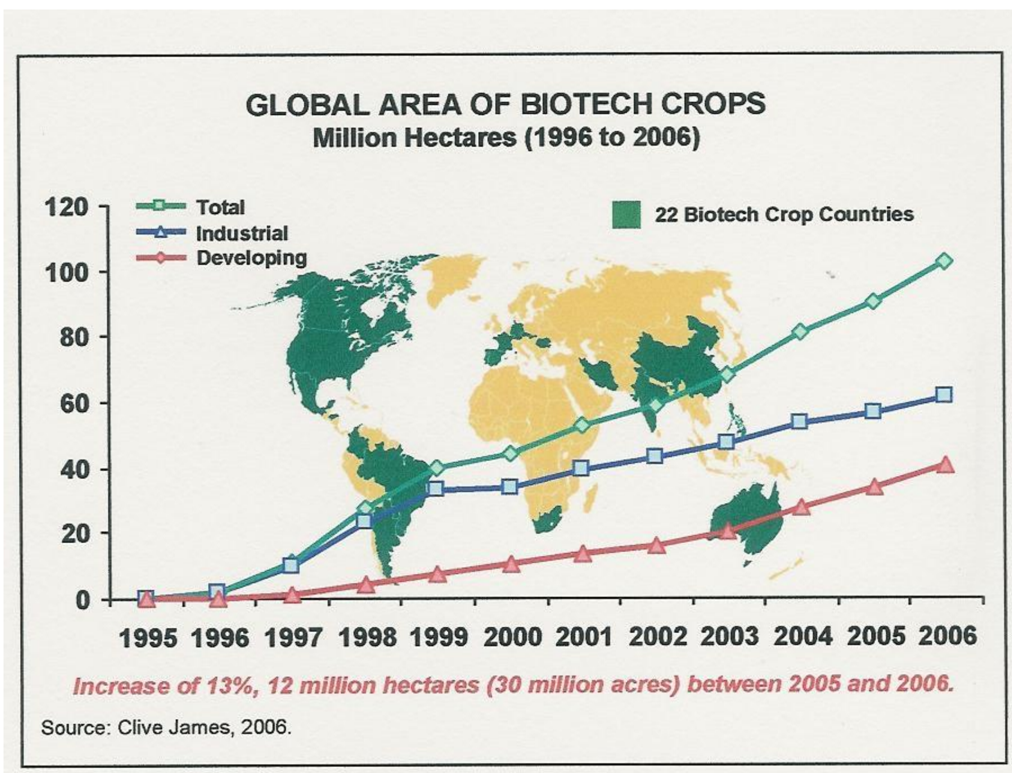

Figure 2.1: The total world area planted to GM crops

2.2 International trade related agreements on GMO issues

Three international organisations are directly involved in setting up harmonised rules, standards and recommendations related to the international trade in GM crops, namely the Codex Alimentarius, the Cartagena Protocol on Biosafety, and the World Trade Organisation (Gruère, 2006).

- The **Codex Alimentarius** is an intergovernmental organisation jointly managed by the United Nations' (UN) Food and Agricultural Organisation (FAO), and the World Health Organisation (WHO). Its main purposes are to protect the health of consumers and to promote fair practices in international trade. In 2003 the Codex Commission reached an agreement on issues of food safety and has as a result published the following three documents:
    - Principles for the risk analysis of foods derived from modern biotechnology;
    - Guideline for the conduct of food safety assessment of foods derived from recombinant-DNA plants; and
    - Guideline for the conduct of food safety assessment of foods produced using recombinant-DNA micro-organisms.

  The Commission has however not yet reached any agreement on the issue of GM food labelling. This means that member countries are still free to institute labelling regulations at their own discretion.

- The **Cartagena Protocol on Biosafety (CPB)** was introduced in January 2000 as part of the United Nations' Convention on Biosafety to set up a harmonised framework of risk assessment, risk management and information sharing on the transboundary movement of Living Modified Organisms (LMOs). The protocol was approved in January 2002 by the representatives of 130 countries and eventually came into force in September 2004. The CPB allows importers of LMO's that are intended to be planted in the importing country, to request information on the food and environmental risk of the GM crops. It also allows the importing country to ban the importation of specific GM events as a precautionary measure for a limited period until a satisfactory risk assessment is provided; this raises the question of what a fair limited period is. LMO's that are not intended to be planted but to be consumed as food, feed or industrial inputs are not subjected to the full biosafety procedures as they are not intended to be released into the environment, but importing countries may request information from exporters on the presence and identification of LMOs in every shipment. This raises questions on the degree of detail and on a threshold level for the adventitious presence of LMOs not specified in the information. Major issues have arisen as to how a country's biosafety obligations under the CPB should relate to a country's rights and obligations under the WTO and other international agreements. One of the key issues is that the CPB sets minimum standards and that member countries can add additional requirements, which can create opportunities for protectionism.

To date the members have still not agreed on the definitive nature of the various sets of information required or on the issue of a threshold for adventitious presence of non-reported GMO's. Currently the chairperson of the so-called Working Group 1 has drafted a proposed set of rules according to which:

- If a country exports a shipment of non-GMO's with the possible but unknown presence of GM varieties, it must clearly state that the shipment may contain the specific LMO's, it must provide the importing country with a list of identifiers of those events, and it must make sure that the importing country has actually authorised the importation of the specific varieties;
- If a country exports a shipment of known GM products, the exporter must declare that the shipment contains the specific GMO's, it must provide the importing country with a list of identifiers of those events, and it must make sure that the importing country has actually authorised the importation of the specific varieties; and

- If a country exports a shipment of non-GMO's it would not be required to state anything provided there is no detected GM content over the possible threshold level decided on by the importing country.

These proposals are now supported by all members of the BSP except Brazil and New Zeeland, and it seems likely that the members may eventually agree on rules based on these proposals.

- The **World Trade Organisation (WTO)** does not have a mandate on GM food regulations, but the rules of the WTO may be brought into question when GM regulations act as barriers to trade. In this regard, two WTO agreements come into play, namely the Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) and the Agreement on Technical Barriers to Trade (the TBT Agreement). The SPS agreement rules in a dispute on the validity of GM food safety regulations (including bans), and the TBT agreement rules in a dispute on GM food standards and regulations (such as labelling) if the regulations are regarded as more stringent than necessary for safety and are therefore potentially trade distortive. Members countries have to notify the SPS and TBT Committees of the WTO of any new or changed SPS and technical (e.g. labelling) measures respectively that may affect trade. By the end of April 2005, 22 countries had lodged 111 notifications related to GMO's with the SPS Committee, and 19 countries had lodged 69 such notifications with the TBT Committee. In addition, 47 members have adopted domestic regulations on GM food based on their own standards. This emphasises the existing lack of clarity on the various agreements on GM related trade.

  In the case of a trade related dispute between member countries they can file a dispute with the WTO, in which case a Dispute Settlement Panel will be instituted to arbitrate the dispute. If the panel concludes against a particular country, the country could change its regulations to comply, or it may decide to maintain its regulations and suffer the consequences of any possible retaliatory measures that may be instituted against it. In October 1998, the EU decided to stop the consideration of new GM events for approval and to wait for more information on the biosafety of the GM events. The USA, Canada and Argentina considered this to be a de facto moratorium and in 2003 they filed a dispute with the WTO on this. In 2004, the EU, in anticipation of the dispute panel's findings, lifted the ban and replaced it with more stringent labelling and traceability regulations. Six EU member countries (Austria, France, Germany, Greece, Italy and Luxemburg) however maintained the ban on maize and rapeseed varieties. On 7 February 2006 the Dispute Settlement Panel eventually sent its findings in a confidential report to the four countries involved for their evaluation and rejoinders. The final report of nearly 1100 pages was released to the general public on 29 September 2006. The Panel concluded that the EU had indeed applied a general de facto moratorium on a number of rapeseed, sugar beet, fodder beet, maize and cotton varieties and that the moratorium was inconsistent with the EU's obligations in terms of the SPS Agreement. The Panel also concluded that the ban by the six member countries on a number of maize and rapeseed varieties were not consistent with the safeguard measures provided for in the SPS Agreement. In the light of these conclusions, the Panel recommended that the Dispute Settlement Body request the European Communities to bring the relevant member State safeguard measures into conformity with its obligations under the SPS Agreement. To date it is not clear how the EU will finally respond to this recommendation.

In conclusion, the main issue in the international arena now remains the labelling and traceability regulations. These are at this stage still well outside the ambit of international agreements and can be abused to affect the international trade in GM products. There remains a large divergence in the GM rules and regulations of different countries, and as new developments evolve, countries will continue to amending their biosafety stances and regulations.

2.3 The GM maize situation in the major maize exporting countries

2.3.1 General background

For the world in total, the area planted to GM maize increased from 0,3 million hectares (or 0,2% of the total area planted to maize) in 1996, to 25,2 million hectares (or 17% of the total maize area) in 2006. To date, the development of the various GM maize events has mainly targeted the achievement of herbicide tolerance (notably Roundup) and insect resistance (notably stalkborer) in maize cultivars in order to reduce the use of herbicides and pesticides and to decrease the cost of production. However, it was discovered that these developments have also had yield increasing effects in the production of maize. Various researchers have found/assumed yield advantages from 7,5% to 11,3% over conventional maize[3], whilst GM companies interviewed indicated that a yield advantage of 10% would probably be a best generalised approximation.

According to Brookes and Barfoot (2006), GM technology has at farm level resulted in significant improvements in productivity and profitability. The farm income benefits from GM maize for the period 1996 to 2005 was estimated at US $1957 million in the USA, $159 million in Argentina, and $59 million in South Africa. In addition to these benefits, GM technology has also led to important socio-economic and environmental advantages. "The GM technology has delivered economic and environmental gains through a combination of their inherent technical advances and the role of the technology in the facilitation and evolution of more cost effective and environmentally friendly farming practices." (Ibid, p. xv).

Against this background, it is clear that GMO maize is here to stay and that the adoption thereof by producing countries will undoubtedly continue to increase.

Table 2.2 shows the share in world maize trade of the major maize exporting countries. The USA is by far the largest supplier of maize to the world market, followed by

[3] See for instance Brookes (2002), Gouse *et al* (2005) and Brookes and Barfoot (2006)

Argentina, China and Brazil; these four countries together supply 91% of the total world maize exports. The GM maize adoption rate and regulations on GMO's will therefore be of special relevance to the world supply of GM maize.

Table 2.2: The maize exports from the world's major maize exporting countries, average for the 2002/03 to the 2006/07 marketing years

Country	Total exports (million tons)	Percentage of world total (%)
United States (USA)	50 867	62,8
Argentina	13 180	16,3
China	5 274	6,5
Brazil	4 465	5,5
Rest of the world	7 263	9,0

Source: FAS (2007)

2.3.2 The GM maize situation in the USA

The USA is the world leader in the development of GM maize events. It has to date approved 22 GM maize events for general release and makes no distinction between approved GM and non-GM maize. Figure 2.2 shows the rapid adoption of GM maize cultivars in the USA (from 4% of the total area in 1996 to 61% in 2006).

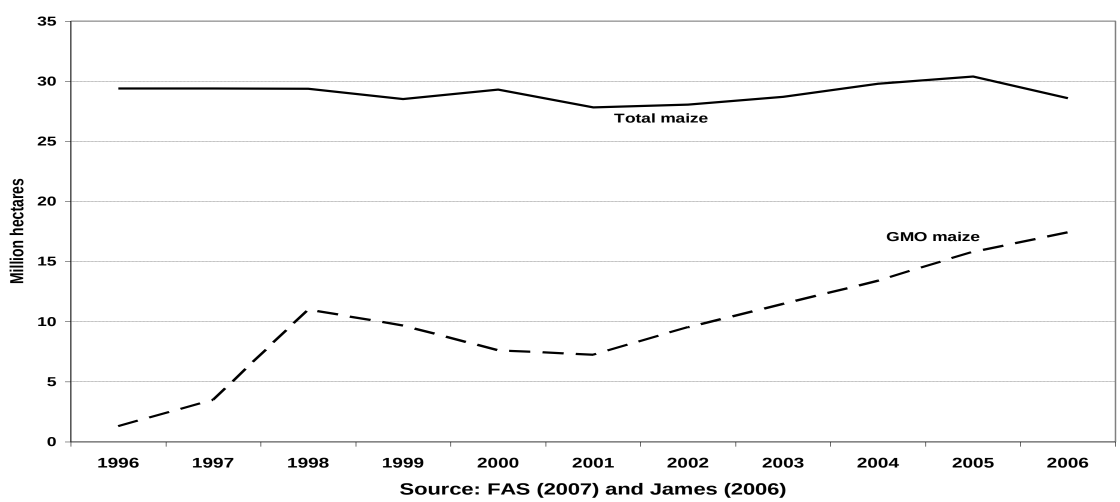

Figure 2.2: The total area planted to maize in the USA, versus the area planted to GM maize, since 1996

At this stage traders find it very difficult to segregate GM maize from non-GM maize and the Federal Grain Inspection Service (FGIS), the grain certification arm of the US Department of Agriculture (USDA), is no longer prepared to certify maize export consignments as non-GM. It is said by many that the high GM maize adoption level has adventitiously contaminated most of the non-GM maize and that few traders are prepared to accept the risk to guarantee the delivery of non-GM maize. Exporters have to rely on private testing institutions and accept the risk that the maize may be GM positive on retests by the importing countries and may be rejected in the port of destination.

2.3.3 The GM maize situation in Argentina

Figure 2.3 shows that the maize producers in Argentina have adopted GM technology at an extremely rapid rate, with the area planted to GM maize increasing from 5% of the total area planted in 1999 to 67% in 2006. This high rate of adoption makes it virtually impossible to procure non-GM maize from Argentina.

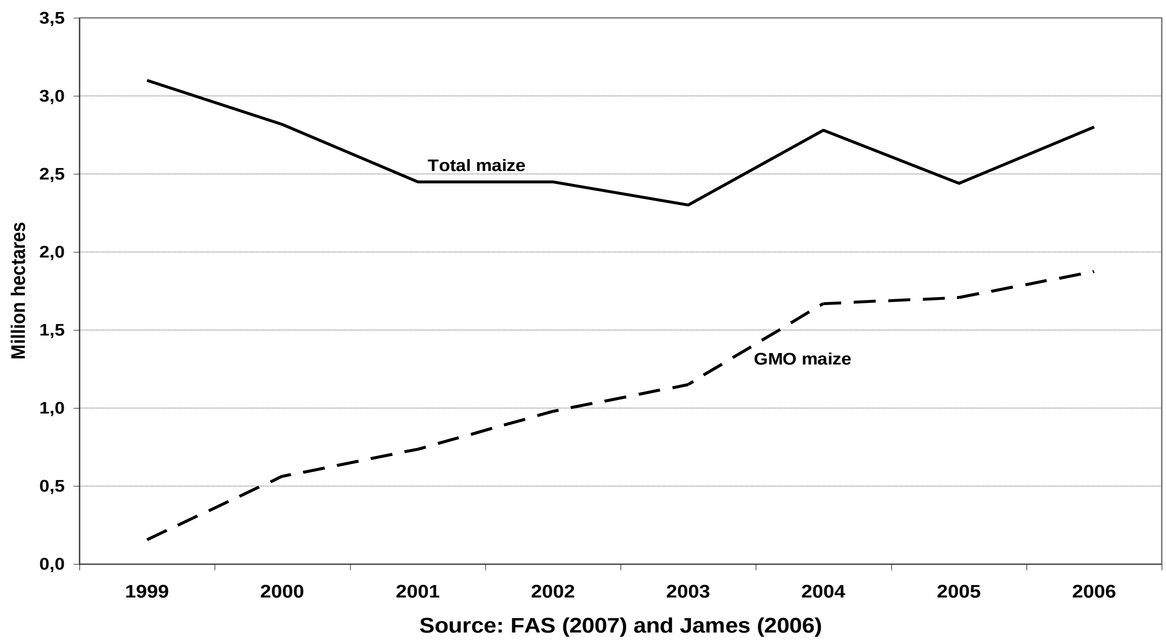

Figure 2.3: The total area planted to maize in Argentina versus the area planted to GM maize since 1999

Argentina has to date approved 8 GM maize events for general release and these have all been approved in South Africa for either general release or commodity clearance[4]. This means that Argentinean maize can be quite readily be imported into South Africa.

2.3.4 The GM maize situation in China and Brazil

In contrast to the USA and Argentina, China and Brazil have to date not yet approved any GM maize varieties for general release and are at this stage the major suppliers of non-GM maize to the world market.

Although China has not yet approved any GM maize varieties for general release, it does have a significant number of GM maize varieties in the field-testing phase. It has also approved a number of GM events for commodity clearance (i.e. for importation and domestic consumption). According to James (2006), Chinese policy makers view agricultural biotechnology as a strategic vehicle to increase food security and to improve agricultural production and competitiveness. China is a major producer of GM cotton with an adoption rate of around 66%, and is currently field-testing GM varieties of maize, rice, wheat potato, tomato, soybean, cabbage, peanut melon, papaya, sweet pepper, chilli, rapeseed and tobacco. China currently has 200 government funded biotech labs and has 500 companies active in biotechnology. It is expected that the Chinese farmers will start planting GM maize on a commercial scale in 2007 and that the GM maize adoption rate will be very high.

The Brazilian authorities have taken a long time to sort out their agricultural biotech regime. However, in March 2005 the Brazilian Congress promulgated a biosafety act which provided a legal framework for the approval and adoption of GM crops in Brazil. It provided, amongst others, for the first time, for the sale of GM soybean seed and approved the use of Bt cotton (James, 2006). The Brazilian farmers have expressed a

[4] Events that are approved for general release may freely be planted and processed/consumed; events approved for commodity clearance may not be planted but may be imported for domestic processing under specific regulations to prevent the release of such maize into the environment.

strong intention to plant GM soybeans and it is projected that 55% of the area planted to soybeans in the 2006/07 season could be GM.

Although Brazil has to date not yet approved any GM maize events for general release, the delays in the finalisation of the legal framework has caused an extensive backlog of accumulated applications and, according to James (2006), there are applications pending for both BT and herbicide tolerant maize which have the potential to increase productivity significantly. It is therefore expected that the area planted to GM maize in Brazil will rapidly increase over the next few years.

Against this background, China and Brazil should for the foreseeable future continue to be major suppliers of non-GM maize to the world market, but at the same time it is expected that the premiums for non-GM maize from these countries will soon start to increase (as the farmers will increasingly demand premiums to plant non-GM maize and the cost of segregation and identity preservation will increase).

2.4 The GM maize situation in the major maize importing countries

2.4.1 General

Table 2.3 shows the average maize imports of the major maize importing countries. Unlike the maize export situation, the maize import situation is not dominated by only a few countries, but nevertheless, 5 countries are responsible for around 66% of all world imports. Of these, the GM regulatory systems in Japan and the EU are of primary importance as they tend to set the example for larger regions.

Most non-EU countries in Europe are adopting regulations similar to those of the EU, whilst South Korea, Thailand and Indonesia have similar regimes as Japan (Gruère, 2006). In this regard, though, Mexico and Taiwan seem to be notable exceptions.

Table 2.3: The maize imports into the world's major maize importing countries, average for the 2002/03 to the 2006/07 marketing years

Country	Total imports (million tons)	Percentage of world total (%)
Japan	16,4	22,3
South Korea	8,8	12,0
Mexico	7,4	10,1
Taiwan	4,5	6,1
EU-27	4,0	5,4
Rest of the world	32,5	44,1

Source: FAS (2007)

2.4.2 The GM maize situation in Japan

Japan imports on average about 12 million tons of maize per year for the feed market and around 4 million tons of maize for the food market (snackfood, starch, popcorn, and oil). To date, Japan has approved 26 GM maize events for either testing purposes or for use in the feed and food industries; these include all the events approved for general release in the USA (AGBIOS, 2007). Japan has no substantial commercial production of biotech crops and, although a number of public research institutes are actively engaged in plant and industrial biotech research, there are no products in the pipeline for domestic production (Hamamoto, 2006).

Although the Japanese food industry and the government are generally receptive to agricultural biotech products, they are also sensitive to consumer concerns. Because of consumer insistence, Japan requires strict labelling on all biotech food products. To date, 31 foods are subject to the requirement because they are made from ingredients that could contain biotech products and because traces of introduced DNA or protein can be identified in them. These foods include soybean products, food products from maize (such as snacks, starch and popcorn), potato based foods, and any item containing lucerne as the primary ingredient. If the weight of the ingredient to be labelled in these foods exceeds 5 percent of the total, the food must be labelled with either the phrase "biotech ingredients used" or "biotech ingredients not segregated." To be labelled "non-biotech," the processor must show that the ingredient received "identity preserved" handling from production through processing. Japan has a zero tolerance for unapproved biotech foods. In addition to these labelling regulations, the food industry and retailers (and particularly large supermarket chains) are hesitant to stock GM food products. This tendency is especially strong for foods and beverages made from soybeans or maize (Ibid).

To assure compliance with the GM regulations, a sampling program is in place that tests shipments at port and tests processed food products at the retail level. Any detection of an unapproved biotech ingredient in a food violates Japan's Food Sanitation Law. If an unapproved product is detected, the shipment must be re-exported, destroyed or diverted for non-food use (Ibid). After the Starlink maize food scare in Japan[5], Japan increased the frequency of food safety inspections on maize from 5% to 50% of all cargoes (Gruère, 2006).

All biotech-derived plant materials to be used as feed in Japan must obtain safety approvals. In feed, there is a 1% tolerance for the unintentional commingling of GM products that are approved in other countries but not yet approved in Japan. To apply for the exemption, the exporting country must be recognized as having a safety assessment program equivalent to or stricter than that of Japan (Hamamoto, 2006).

In summary, the GM regime in Japan has no real restrictive impact on the export of maize for the feed market in Japan. However, it must be concluded that any maize imported for the food market will for the foreseeable future have to be non-GM. It is also fair to conclude that the food demand will be prepared to pay substantial premiums for non-GM maize as this maize is processed into high value food items which can afford to carry premiums.

[5] The presence of the GM maize event, Starlink, was discovered in a cargo of maize shipped from the USA to Japan. At that stage, Starlink was approved by the USDA for feed consumption but not yet by the FDA (Food and Drug Administration) for food consumption.

2.4.3 The GM maize situation in the European Union (EU)

Gruère (2006) describes the EU's GM regime as "precautionary, process related" (p.33) and, according to him, the EU has the most comprehensive regulations on GM food of all countries. The regime has become increasingly stringent and is often seen as a mechanism for disguised non-tariff barriers to trade. The EU's response to world pressure and the (anticipated) conclusion of the Dispute Settlement Panel of the WTO (as discussed in section 2.2), for instance, was to introduce even more stringent labelling and traceability regulations, to such an extent that food processors and retailers are encouraged to avoid GM ingredients entirely.

All shipments of GM foods and feeds to the EU are tested on arrival. The EU's system demands mandatory labelling of GM food and food additives and flavouring at the 0.9% level in the case of GMs that have been approved in the EU. In the case of GMs that have been assessed as safe but have not formally been approved, the threshold for labelling is at the 0.5% level. This applies to animal feed, food sold by caterers, and food derived from GM ingredients. Zero tolerance applies to GM products or ingredients that have not been assessed for safety and have not been approved for release. The GM material has to be traced from the farm to the consumer. However, no labelling is required for meat, eggs, milk and other products from animals fed with GM feed.

Despite these regulations, though, it would be wrong to perceive the EU to be totally opposed to GM crops. The updated legislation has indeed also culminated in Regulations 2003/1829 and 2003/1830 which opened the door for the biosafety assessment and approval of GM events. In 2006, GM maize was planted in six member states, namely Spain, France, Portugal, the Czech Republic, Germany and Slovenia (Van der Walt, 2007a). The EU Trade Commissioner, Peter Mandelson, has recently warned that unless the EU closes the gap between its own GM approval system and those of countries exporting feed, "hungry cows" and "struggling farmers" will be the result. He also cited a recent report from the European Commission that suggests that Europe might experience increasing problems in sourcing and importing animal feed approved under EU rules, thereby putting a heavy strain on the EU livestock sector. He argued that, with the population of the world projected to reach nine billion by 2050, food demand will double, whilst the fight against climate change will also require agriculture to produce more energy crops and raw materials for industry. According to him, it is simply not responsible or defensible for the EU to refuse to assess the role of GM food in meeting future demands (GMO Compass, 2007).

In other developments in the EU, Spanish scientists have developed a new technique that may result in better nutritional and safety profiles for the next generation of genetically modified plants. In Germany, the Bavarian Higher Administrative Court has recently overruled the judgement of a local court that had ordered the Bavarian State Research Centre for Agriculture during field trials to harvest before blooming or to cut the flowers of GM maize in order to prevent GM traces in honey. The higher court found that current EU legislation neither prohibits the adventitious presence of minimal GMO-traces in honey nor requires labelling if the threshold of 0.9 percent is not exceeded. In France, the French Environment Ministry refused to suspend the domestic growing of MON810 maize, the only GM maize event approved for cultivation in the EU (GMO Compass, 2007).

With these developments, the real hurdle for the consumption of GM food products in the EU is now to overcome the consumer sentiment which had been fuelled by anti-GM lobbyists and retail food chains for many years. One the one hand, the GM labelling and traceability regulations do seriously discourage the production and retailing of GM food in the EU. On the other hand, the major retail chain stores in the EU have a strict non-GM food policy. Sainsbury, a major food retail chain in the EU, claimed in a press release in 1999 that it was the first major UK supermarket to have completely eliminated GM ingredients from its own-brand products (Sainsbury, 1999). Tesco, another major food retailing chain, states their GM food policy as follows: “Our policy on Genetically Modified (GM) foods is driven by the view of our customers. Our research shows that 75% of UK customers do not want GM foods. We do not therefore have any own-brand GM foods on our shelves” (Tesco, 2007). From this it seems as though the major food retailers use their anti-GM food stance as a marketing position. Against this whole background one has to assume that the food market in the EU will be extremely restrictive to GM based foods, including animal products from livestock that have been fed on feed that included GM components.

2.4.4 The GM maize situation in Mexico

Mexico is a major importer of food, feed and fibre, mainly from the USA, and has no trade related constraints on GM crops (Gruère, 2006). Its maize imports are virtually all sourced from the USA, and most of this is GM. However, Mexico is held as the birthplace of maize as maize was domesticated in Mexico thousands of years ago. Maize is an essential part of the Mexican diet (in the form of tortillas), it is grown by more than 3 million farmers, and in some places it is still venerated as a divine crop (Cevallos, 2006). Environmental groups have therefore urged the Mexican government to restrict the flow of GM maize to Mexico.

Mexico has, after many years of debate, approved a biosafety law in 2005 which facilitates the introduction of GM crops. However, in October 2006 Mexico's National Service for Food Safety and Quality has, for the third time since 2005, refused seven requests for trial plantings of GM maize seeds. On the other hand, Mexico is a signatory of the North American Free Trade Agreement (NAFTA) and in terms of this agreement Mexico must by 2008 eliminate all quotas and other barriers to trade on the flow of USA maize and soybeans to Mexico (Cevallos, 2006).

Against this background it is expected that Mexico will continue to allow the free importation of GM maize, but at the same time continue to disallow the domestic planting of GM maize.

2.4.5 The GM maize situation in Taiwan

Taiwan does not produce any GM crops on a commercial scale and there are no GM crops under development that are expected to be planted in Taiwan in the next few years (Perng, 2005).

In Taiwan, the Department of Health (DOH) is responsible for food safety risk assessment while the Council of Agriculture (COA) has oversight on events to be used in livestock and crop production or aquaculture. Although the DOH is mostly left to regulate biotechnology without overt political interference, Taiwan's legislature has in the past considered laws that would seriously impair market access for biotech food in Taiwan, and is considering a new biotech basic law and an import-export regulations, none of these are in final form. Taiwan is also expected to eventually require the registration of all bio-engineered foods, not just corn and soybean events (Perng, 2005).

To date, Taiwan has approved 10 GM maize events and one GM soybean event to be imported for food, feed and industrial processing, but none for planting (AGBIOS, 2007). These events have been approved for general release in most of the GM exporting countries and in this regard they do not form a barrier to trade.

Taiwan requires all food products from GM maize and soybeans to be labelled. The labelling regulations do not apply to products that do not contain pieces of transgenes or protein, such as maize starch, maize syrup, maize oil, soy oil, and soy sauce, and it does not apply to GM maize and soybean products that are not packaged for retail sale. Taiwan uses a 5 percent tolerance level by weight to determine a product's GM status and for GM food labelling. These regulations have been imposed primarily because the Taiwan authorities support the consumers' "right to know" rather than as a food safety issue (Perng, 2005).

With exception of organic food consumers who are generally sceptical about biotech foods, most consumers in Taiwan are not aware of GM food. In general, they continue to purchase food in bulk (unlabelled) and eat traditional Chinese breakfasts with made with biotech soymilk. However, the consumption of processed non-GM food such as soymilk and tofu is gradually increasing because of marketing campaigns by local producers. Most of the retailing stores stay neutral to the GM issue and sell both GM and non-GM products (Perng, 2005).

SECTION 3
THE SOUTH AFRICAN GM MAIZE SITUATION

3.1 The South African GM maize regime

South African biotechnology policy is formulated under the Genetically Modified Organisms (GMO) Act of 1997 as modified in 2006 by the Genetically Modified Organisms Amendment (Act Number 23 of 2006)[6]. The Act provides for a GMO Executive Council, a GMO Advisory Committee, and various regulations. The Act is administered by the Directorate of Genetic Resources of the National Department of Agriculture (DoA). The Executive Council is comprised of the chairperson of the Advisory Committee plus a senior representative from each of eight government departments, namely Agriculture, Health, Environment & Tourism, Labour, Science & Technology, Water Affairs & Forestry, Trade & Industry, and Arts & Culture.

Permits are required for all imports of GM maize, irrespective of whether for contained use, field trials or general commercial release. Every application is assessed for biosafety by the Advisory Committee and inputs from independent reviewers. The recommendations of the Advisory Committee are considered by the Executive Council before a decision is made. Applicants must submit a dossier with all relevant biosafety data pertaining to human and animal health, environment, and socio-economic considerations (impact on small-scale farmers and rural communities). Such data may be generic or specific and may originate from an overseas or local developer and independent laboratories. The Executive Council may request additional data to be obtained under South African conditions. Once an event is approved, the lines and cultivars derived thereof are automatically approved. However, if two events are combined (or "stacked") in one cultivar, a new approval is necessary.

[6] The purpose of the amendment was to bring the act into line with the Cartagena Protocol on Biosafety which South Africa has then signed and ratified.

To date, four maize events have been approved for general release in South Africa (i.e. importation, exportation, commercial planting, and use for food and feed), namely: MON810/Yieldguard (insect resistant, approved in 1997), NK603 (herbicide tolerant, approved in 2002), Bt11 (insect resistant, approved in 2003) and NK603 (stacked herbicide tolerant and insect resistant, approved in 2007). Various other events have been approved for commodity clearance (i.e. for importation but not for domestic production), namely MON810 x NK603, MON810 x GA21, and TC1507 (all stacked genes for insect resistance and herbicide tolerance), GA21 and T25 (both herbicide tolerant), and Bt176 (insect resistant).

In 2005, the South African GMO Council placed a temporary moratorium on the importation of GM events that have not yet been approved for general release or commodity clearance in South Africa, and has commissioned a study on the potential impact of the commodity clearance and importation of GM maize on South Africa's trade in maize. The moratorium will be reconsidered once the outcome of the study is available. The study was completed recently and submitted to the Director of Genetic Resources in the DoA, and it is now up to the GMO Council to decide on the issue.

On 16 January 2004, the Minister of Health issued regulations (R25) in terms of the Foodstuffs, Cosmetics and Disinfectants Act (No 54 of 1972) on the labelling of *"foodstuffs obtained through certain techniques of genetic modification"* (Government Gazette, 2004). The regulations state that "*a foodstuff obtained through certain techniques of genetic modification shall not be sold unless if such foodstuff is labelled as follows …….."* The three main stipulations in this regard[7] are that:

(a) "*If the composition of a foodstuff differs significantly from the characteristic composition of the corresponding existing foodstuff, the label shall contain such*

[7]Other compulsory labelling deals with the presence in plant material of nucleic material or its protein from human or animal source, or animal material that contains animal nucleic acids or its protein derived from human or animal origin from a different taxonomic family. Provision is also made for the voluntary labelling for genetically enhanced claims, subject to being validated and certified by a competent body. Voluntary labelling for non-GM claims has been withheld until the Identity Preservation System has been officially adopted.

additional words or phrases as may be necessary to inform the consumer of its true composition";

(b) "*if the nutritional value of a foodstuff differs significantly from the characteristic nutritional value of the corresponding existing foodstuff, the label shall contain such additional words or phrases as may be necessary to inform the consumer of its changed nutrient content"; and*

(c) "if the mode of storage, preparation or cooking of such a foodstuff differs significantly from that of the corresponding existing foodstuff, clear instructions for use shall be given on the label of such a foodstuff".

The key concept in this regard is significantly different; if the genetically modified foodstuff does not differ significantly from its corresponding non-GM foodstuff, it does not have to be labelled as such.

3.2 Tests for the presence of GM maize

The tests for the presence of genetically modified organisms are either for the presence of the unique DNA promoter or transgene, or for the protein produced by the transgene. The tests can be qualitative (for presence/absence) or quantitative (for degree of presence). There are three tests for GM's, namely:

Strip tests: These are qualitative tests for the presence of the specific protein. They are relatively inexpensive and quick, and some tests can test for three events simultaneously. The tests are very sensitive and traders and processors are well satisfied with them. They cost around R45 per test (costs have decreased considerably over last few years) or R200 to R300 per silo bin tested.

PCR tests: These are quantitative tests for the presence of unique DNA. They are very accurate but relatively expensive and slow. It costs about R780 per test for a test that takes a few days to yield a result, and about R1700 per test for a test that yields a result within one day.

ELIZA tests: These are basically qualitative tests for the presence of the specific protein and can test several samples simultaneously to give a quantitative result. They are less expensive and quicker than PCR tests, but are nevertheless still relatively expensive and slow; it takes up to 24 hours per test and costs between R150 and R800 per test (depending on number of samples to be tested). They cannot test proteins that have been denatured (e.g. exposed to high heat).

The buyers/ processors of maize and the regulatory authorities in the importing countries prescribe which tests are to be done.

Problems with the certification of non-GM/GM are not with the tests themselves but with the sampling of the consignment to be certified. One sample may for instance test negative whilst a second may test positive simply because it may incidentally have missed or included a GM kernel. The result is that maize consignments that have been certified as non-GM may sometimes test GM positive when re-tested. The resultant costs of a positive retest on delivery can be extremely high as the buyer may reject the consignment, accept it on penalties, or demand replacement.

3.3 The production of GM maize in South Africa

The South African maize producers adopted GM technology very rapidly. Figure 3.1 shows the total area planted to maize since the 2000/01 production year and the percentage thereof planted to GM maize; in the 2006/07 production year, GM maize already comprised 48,3% of the total area planted to maize.

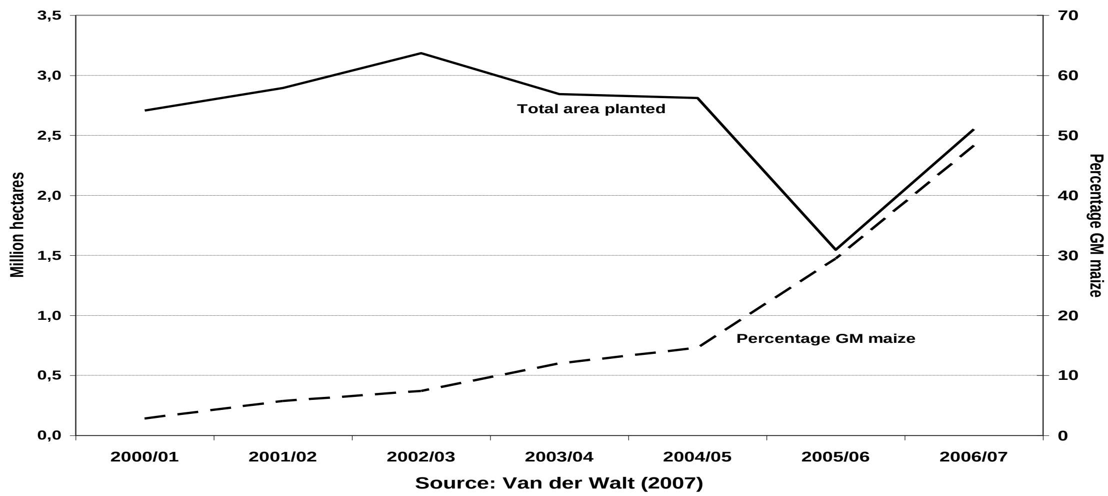

Figure 3.1: The total area planted to maize in South Africa and the percentage thereof planted to GM maize since the 2000/01 production year

Table 3.1 shows a breakdown of this area into more detail. Figure 3.2 shows the rates at which the producers adopted white and yellow GM maize, expressed as the area of GM maize planted as percentage of the total area respectively. In both cases the adoption rate is high, and the lag in the white maize adoption rate is only because yellow GM cultivars became available in South Africa three years before white GM cultivars did. The adoption rates do not yet show any signs of slowing and it could confidently be assumed that the swing to GM maize on the production side will continue for the foreseeable future.

Table 3.1: The area planted to GM maize in South Africa

Production year	GM white maize			GM yellow maize			All GM maize		
	IR (‘000 ha)	HT (‘000 ha)	Total (‘000 ha)	IR (‘000 ha)	HT (‘000 ha)	Total (‘000 ha)	IR (‘000 ha)	HT (‘000 ha)	Total (‘000 ha)
2001/02	6		6	160		160	166		166
2002/03	60		60	176		176	236		236
2003/04	144		144	197		197	341		341
2004/05	142	5	147	249	14	263	391	19	410
2005/06	221	60	281	107	68	175	328	128	456
2006/07	552	152	704	391	137	528	943	289	1232
IR = insect resistant; HT = herbicide tolerant									

Source: Van der Walt (2007b)

The above adoption rates are for the events that are currently available, and the availability of new events will obviously influence these rates. According to the domestic seed industry, the area planted to GM maize may grow to 60% of the yellow maize area and 70% of the white maize area.[8]

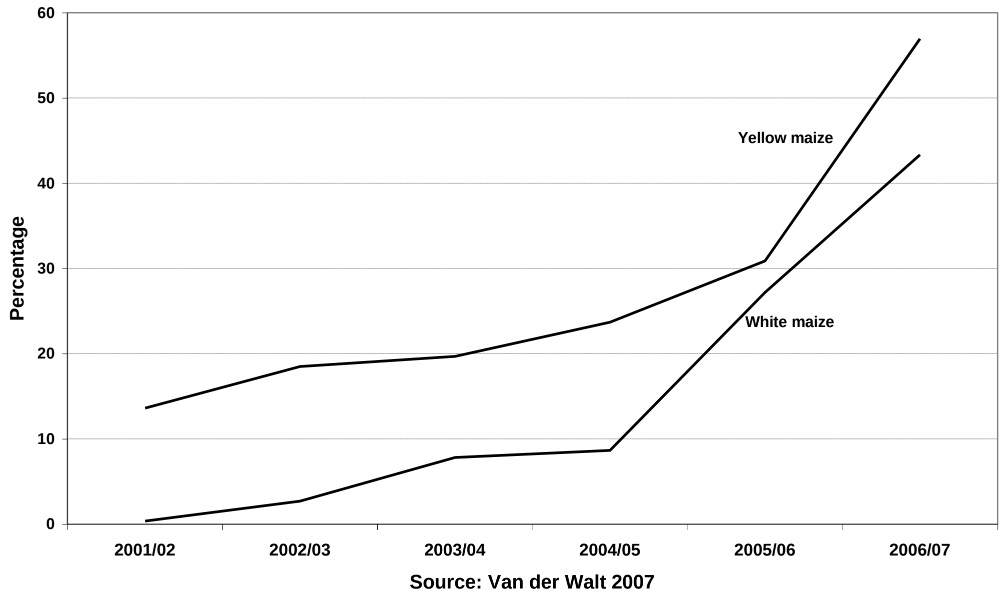

Figure 3.2: The adoption of white and yellow GM maize in South Africa since the 2000/01 production year

The GM maize technology not only benefited commercial farmers, but also small-scale farmers. Gouse *et al* (2005) found that in the 2000/01 and 2001/02 years, Bt maize had a 11,03% and 10,60% yield advantages over conventional varieties under irrigation and dryland conditions respectively. In addition, it enabled significant savings on pesticides, it did not carry any commodity price penalties, but had higher seed cost. In balance, the net benefit of Bt maize for commercial farmers was on average US $24 per hectare on dryland conditions in the North West Province, US $47 per hectare dryland in Mpumalanga, US $85 per hectare under irrigation in Mpumalanga, and US $149 per hectare under irrigation in the Northern Cape. Gouse *et al* (2005) also found that Bt

[8] The reason for the difference is that the advantages of yellow Roundup Ready cultivars are not as significant in the drier western areas as in the eastern areas, but BT maize has an added advantage on white maize which is usually planted later than yellow maize and is therefore more exposed to stalk borers.

maize had significant yield and profit advantages for small-scale farmers in various farming areas.

According to several researchers and stakeholders in the maize seed industry, new GM maize developments that could be released during the next 10 years are events with a wider spectrum of insect control and/or a wider window of herbicide application (i.e. more stacks of events)[9], drought tolerance (less than 5 years away with already 238 approved field trials in the USA), specific product qualities, and medicinal properties. The advent of the stacked events will undoubtedly encourage the further adoption of the technology, and when the drought tolerant events become available, the adoption could become virtually 100%. Events with special product qualities will probably serve smaller niche markets at specific premiums, and events with medicinal properties will probably not be grown on a large scale as it will require total isolation.

If a farmer plants GM maize in South Africa, he must sign a contract with the supplier of the seed to adhere to certain prescriptions that are mainly (a) to plant specified areas of non-GM maize to ensure that stalkborer insects do not develop immunity to BT maize, and (b) to maintain specific separation distances from non-GM maize fields. There are currently a number of areas where farmers have agreed not to plant GM maize in order to seek non-GM premiums. These areas are in the Middelburg/Ogies/Bethal districts in Mpumalanga, and in the Hopetown, Luckhoff, Prieska and Marydale districts in the Northern Cape.

South African farmers currently do not receive large premiums for non-GM maize. Under dryland conditions, the premiums currently vary between R nil and R40 per ton; under irrigation the premiums are around R75 per ton due to higher rates of herbicide and insecticide applications and the high cost of aerial applications of chemicals. Given the current prices of maize of more than R1000 per ton and the bother to comply with the non-GM protocols, these premiums are insignificant, and it is clear that the farmers will

[9] BtR R stacked genes were approved in February 2007 and will be adopted rapidly as seed becomes available.

demand increasing premiums to plant non-GM maize as the economic advantages of GM maize increase.

3.4 The demand for non-GM maize in South Africa

3.4.1 The food market

To date there is no evidence of any significant consumer resistance to non-GM maize based food products in South Africa, and the number of consumers that will pay a premium for non-GM foods seems to be extremely small. Most retailers of food do not require any special labelling for products derived from GM maize, and as such products are not judged to be "significantly different" from non-GM based food products, they are not required per regulation to be labelled as such. The notable exception is a food retailer that positions itself as a provider of high quality foods; this retailer labels its own brands of food products where relevant as "May contain GMO's" or "May be from genetically modified crops", but these labels are hardly noticeable and has as yet not evoked any negative consumer responses.

In contrast to the consumers of maize based foods, the manufacturers of breakfast cereals do demand non-GM maize. This demand is reportedly based on concerns that the consumers may at some stage be incited (e.g. by the media or environmental activists) to reject foods that may contain GMO's. The breakfast cereal demand for maize is however very small (around 8000 tons of yellow maize equivalent) and because it is a high-priced demand sector, the manufacturers will pay significant premiums to ensure supply until it becomes evident that the South African consumers have clearly accepted GM foods.

3.4.2 The feed market

The domestic feed manufacturers have no demand for non-GM maize. According to them it will be too expensive to manufacture, and whilst it is still possible to procure non-GM maize (from the domestic or international markets), they will in any case be forced to use

GM soybean meal as it will be extremely difficult and expensive to procure sufficient quantities of non-GM soybeans or soybean meal. Their customers have also no demand for non-GM feeds and do not seem willing to pay any sort of premiums for non-GM feeds.

3.4.3 The industrial market

The wetmilling industry in South Africa is generally referred to as the industrial sector of the demand for maize. The industry manufactures a range of non-GM starches and syrups from maize, including maltose and glucose for the beer brewing industry (to the equivalent of about 180 000 tons of maize per year). In total, the industry reportedly uses about 600 000 tons of white and yellow maize per year, all strictly non-GM. It supplies the domestic food market with a range of sweeteners, starches and other products and exports around 50 000 tons of maize equivalent products per year to international customers that insist on non-GM products (according to the industry, this number is however decreasing due to the relatively high price of South African maize and the high and increasing cost to procure non-GM maize).

The extent to which the food sector demand for non-GM maize products from the wetmilling industry will continue to pay premiums for non-GM maize products is not known, although is must be accepted that this demand will at some stage start to be rationed if the premiums for non-GM maize continues to increase. The beer brewing industry does have an alternative to maize based maltose and glucose in that it could switch to barley malt if the premiums for non-GM maize become too high. However, this will cause the beer to loose its typical lightness, and the brewing industry may well be prepared to suffer quite a large non-GM premium before it does such a substitution.

As in the case of the food market demand for non-GM maize, the industrial demand for non-GM maize is based on concerns that the industry will suffer a serious decrease in demand if the consumers their products may at some stage be incited to reject GM based products.

3.5 The importation of maize into South Africa

Table 3.2 shows the commercial imports of maize into South Africa since the 2003/04 marketing year. Argentina is by far the dominant origin of imports and this is virtually all yellow maize for the coastal livestock feed manufacturers.

Table 3.2: South African maize imports per country of origination for the 2003/04 to 2006/07 marketing years

Country	White maize	Yellow maize	Total maize	
	(‘000 tons)	(‘000 tons)	(‘000 tons)	(%)
Argentina	0	1 887	1 887	96,6
USA	33	24	57	2,9
China	0	8	8	0,4
Others	1	0	1	0,1
Total	34	1 919	1 953	100,0

Source: SAGIS (2007)

No GM maize may be imported into South Africa unless a permit has been issued by the Directorate: Genetic Resources of the DoA. On application for a permit, the relevant competent authority in the exporting country must declare which GM maize events, if any, have been approved for general release in that country. If any such events have not been approved in South Africa for general release or commodity clearance, the Directorate requires a PCR test from a competent institution that the consignment does not contain any such events. The South African authorities do not test the maize again on arrival in South Africa, and this is despite the fact that imported maize that was certified as non-GM in the exporting country may prove to be GM positive if tested on delivery.

3.6 The export demand for South African maize

Table 3.3 shows the destinations of South Africa’s commercial maize exports since the 2002/03 marketing year, in order of importance. South Africa’s immediate neighbours are by far its most important maize clients, followed by Kenya, Japan and Zambia and

Iran. The maize demand of the neighbouring countries is for non-GM, as is the demand in Kenya, the food market in Japan, and in Zambia.

Table 3.3: The export destinations of South African white and yellow maize, ranked in order of importance, for the 2003/04 to 2006/07 marketing years

Country	White maize	Yellow maize	Total maize	
	('000 tons)	('000 tons)	('000 tons)	(%)
Zimbabwe	1 755	28	1783	39,2
Botswana	546	44	590	13,0
Lesotho	392	22	414	9,1
Namibia	252	66	318	7,0
Mozambique	315	0	315	6,9
Swaziland	92	142	234	5,1
Kenya	220	0	220	4,8
Japan	0	123	123	2,7
Zambia	96	0	96	2,1
Iran	0	93	93	2,0
Malawi	68	0	69	1,5
Angola	67	1	68	1,5
Tanzania	54	0	54	1,2
Indonesia	0	50	50	1,1
Others	104	21	124	2,7
Total	3 962	590	4 552	100,0

Source: SAGIS (2007)

The non-GM certification of maize exports out of South Africa is not mandatory (in contrast to quality and sanitary and phyto-sanitary certifications). The countries of destination have different regimes regarding GM maize, and every country specifies the certification it requires for non-GM maize; this can vary from a certificate issued by the South African government to a declaration and strip test certificate from the exporter. Countries like Japan, the EU, Korea and Kenya have PCR tests done on every consignment before allowing vessels to be discharged. Sub-Saharan African countries, in contrast, do not retest on delivery and rely on the certification from the South African government or the exporter as the case may be. Government certificates are issued by the Directorate: Genetic Resources of the National Department of Agriculture. For this, the

Directorate requires a PCR test certificate from an acknowledged laboratory and a supporting affidavit from the exporter.

The GM regime in Japan is discussed in Section 2.4. As far as the GM maize regimes in the sub-Saharan countries are concerned, South Africa and 13 other countries have formed the Southern African Development Community (SADC); these are Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, Swaziland, Tanzania, and Zambia. These countries had agreed to develop a common biotechnology policy and in August 2003 they accepted guidelines to cover issues such as policy development and regulation, the handling of food aid, and measures to increase public awareness of biotechnology and biosafety. The guidelines assert that the region and the members should develop compatible policy and regulatory systems that are based on either the Cartagena Protocol on Biosafety, or the African Model Law on Biosafety. The heads of member states also agreed to develop national biotechnology policies and strategies, and to increase their efforts to establish national biosafety regulatory systems. Member states were also urged to commission studies on the implications of biotechnology for agriculture, the environment, public health and socio-economic impact (Bickford, 2006). However, except for South Africa and, very recently Kenya, the others have not yet made much progress in this direction.

In this regard it is perhaps useful to discuss the development path of the GM regime in Kenya in some detail as it could be an example of the time path that the regimes in the other SADC member countries could follow. In August 2005, the Kenyan government ordered the destruction of all Bt maize field trials because their environmental impact had not fully been assessed. In September 2006, the Kenyan cabinet approved a National Biotechnology Development Policy which includes how biotechnology is to be handled in research, development, and application. In July 2007, the Kenyan government published a Biosafety Bill for debate. It is expected that GM maize will have notable advantages over non-GM maize in Kenya and that, should the bill be approved, the Kenyan farmers will adopt GM maize at a fairly rapid rate. It has just (August 2007) been announced that the Kenya Agricultural Research Institute and the International Maize and

Wheat Improvement are set to repeat the confined field trial for Bt maize (ABSF, 2007). And although Kenya has at this stage primarily still a non-GM import regime and requires all maize consignments to be tested on arrival, it will accept GM maize imports if prior declared as GM and labelled accordingly.

The other SADC member countries are mostly all in the process of developing biosafety guidelines and policies. At this stage these countries have not approved any GM crops for general release or commodity clearance although some of them do have research and development projects on GM maize and/or other crops. The countries do not test any consignments on arrival and accept exporter certification for non-GM status. With the exception of Zambia, these countries all allow the importation of GM grains provided it is milled before or on arrival and is declared as GM. Zambia doesn’t accept any GM grains in any form.

3.7 The storage and identity preservation of non-GM maize in South Africa

The South African silo industry finds it increasingly difficult to procure and identity preserve non-GM maize. The main problem is the incidental co-mingling of GM maize on the farms and in the silo’s, and the grain warehousing companies have different practices and cost rates in this regard.

Some of the companies are quite extensively involved in the procurement and storage of non-GM maize. They will contract for non-GM maize with farmers that grow non-GM maize and follow prescribed non-GM production protocols; they will manage non-GM contracts for buyers with such farmers (they test the maize before harvesting on the farms for GM’s, test again on intake at the silo’s, and test in the silo’s before outloading). They use strip tests and guarantee the maize to buyers as non-GM. The cost to the buyer for these services is negotiable from zero to around R30 per ton.

Others do not contract with farmers on their own behalf but do manage contracts with farmers for other buyers; they do the full IP protocol and guarantee the maize, and for this service in the irrigation areas they negotiate premiums of R80 to R100 per ton with buyers. Others will test every maize silo for GM presence after the crop is delivered and seal those that test negative; they will indicate such silo's to buyers as possibly non-GM but the buyers must accept the risk, and the price of this service is negotiable around R25 to R35 per ton. Finally, some companies do not offer any non-GM services at all.

Whilst the grain warehousing companies store grain in large concrete structures in which it is increasingly difficult to identity preserve and guarantee non-GM maize, a new development in the industry that can alleviate this problem is the advent of grain silo bag systems. According to Grutter (2007), the systems were first introduced into South Africa in 2005. The heart of the system consists of hermetic plastic bags that can store 190 tons of maize, 190 tons of wheat, 100 tons of sunflower seed, or 180 tons of soybeans per bag. The cost of storage in the system is around R45 per ton, which makes it comparable to the cost of conventional storage. In addition, the bags are located on the farms and facilitate the separation of grain by quality etc. During the 2005/06 marketing year, farmers and traders stored approximately 300 000 tons of grain in the systems; during the 2006/07 year, a total of 500 000 tons were stored in the systems, and it is expected that around 700 000 tons will be stored in the 2007/08 marketing year.

3.8 The procurement of non-GM maize in South Africa

Non-GM maize is procured in South Africa mainly in four ways, namely:

(a) Processors/traders contract directly with farmers to grow the maize on a specified IP protocol and contract silo owners to manage the contracts and do the storage;

(b) Processors/traders contract with farmers and store the maize in their own or in the farmers' silobags;

(c) Processors contract with traders to supply non-GM maize; and

(d) Silo owners indicate to buyers the silo's that may be non-GM, with the buyers doing the testing and accepting the risks.

Premiums for non-GM maize are increasing. In the conventional storage environment, the farmers earn up to R40 per ton for non-GM in dryland production and up to R75 per ton under irrigation (due to higher usage of chemicals and high cost of aerial application). The silo owners' premiums are also increasing and currently vary from R10 to R35 per ton. The traders' premiums vary between R30 to R40 per ton. In the silo bag environment the traditional silo owner's share is split per negotiation between the farmer and the buyer. The premiums that the farmers demand, will increase as the productivity of new GM varieties increase, and the premiums that the storage industry demand will increase as the farmers' adoption of GM maize increase and it becomes more difficult to separate GM and non-GM maize.

SECTION 4

QUANTITATIVE APPROACH TO THE MODELLING OF THE TRADE IMPACTS OF VARIOUS SCENARIOS

4.1 The GTAP model

The GTAP model is generally accepted by researchers as the most suitable tool to analyse the impact of trade related policy decisions on trade flows and national welfare due to its regional and sectoral coverage, as well as its theoretical compliance. It is a multi-regional, computable general equilibrium (CGE) model that was developed by Prof. Hertel at the University of Purdue in collaboration with the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) in Australia. It is a comparative static model that allows for a base period scenario to which trade "shocks" could be applied to simulate the outcomes of specific trade policy measures. The model describes both the vertical and horizontal linkages between all product markets both within the model's individual countries and regions as well as between countries and regions via their bilateral trade flows (Jooste et al., 2003). The trade data in the model's database is regularly updated, and the latest version of the model, Version 6, consists of 87 regions with 57 sectors of economic activity based on 2001 data.

On the production side the model assumes that all markets operate under conditions of perfect competition, which allows resource allocation decisions to be analysed using the Leontief and constant elasticity functions because of constant returns to scale. Each commodity is supposed to be produced by a distinct sector using intermediate inputs that is sourced domestically and from all over the world (Stone et al., 2002). Within the production, capital formation and trade sectors, prices reflect perfect competition. Thus sellers earn no pure profits and costs determine revenues. This implies that the percentage change in the price of any commodity will equal the weighted sum of the percentage changes in the prices of the inputs.

On the demand side the model has three sectors, namely: private households, government, and savings. At the macro level a variable share of regional income is compiled of household- and government consumption and net savings in each region. Households are assumed to consume a CES composite of domestic and imported commodities. Income and price elasticities of demand are specified for each region, which allows a detailed representation of demand conditions (Hertel, 1997).

Trade is modelled as a series of import and export flows defined by commodity and region of origin or destination. Armington elasticities are defined as regionally standard across all agents, which mean that import demand equations differ only according to their import shares (Stone et al., 2002). Careful definition of imports and exports categorised by agent is important where import intensities of the same commodity differ greatly across uses because it allows trade payments to be traced to specific sectors of the economy like private households, government or firms (Brockmeier, 1996).

4.2 Adjustments to the GTAP database

The relevance of the model's calculations depends on the accuracy of its database. In this study it was found that the database needed to be adjusted in order to better reflect the South African trade in maize; the reason for this is that the model's database primarily focuses on the trade situations of the major countries and does not adequately discern the tradeflows of the smaller countries. In order to do this, the regions and sectors in the model were firstly aggregated to 22 and 17 respectively to make it more manageable. Secondly, as the model categorises maize together with various other grains (barley, rye, oats, sorghum, millet and some other minor grains) in a sector called "Cereal grains not elsewhere classified", this sector had to be disaggregated into "maize" and "other cereal grains". This was done according to the relative share of maize production in the "Cereal grains not elsewhere classified" sector of each of the 22 aggregated regions in the model (Table 4.1). The adjusted model, however, still produced maize trade flows that were inconsistent with actual flows in the base period, and this necessitated further corrections to the database.

Table 4.1: The 2004 share of maize in the category, "Cereal grains not elsewhere classified", of the various regions of the GTAP model

Regions	"Other cereal grains" (%)	Maize (%)
1 China	7	93
2 Japan	100	0
3 Rest of Asia	32	68
4 USA	7	93
5 Mexico	27	73
6 Argentina	20	80
7 Brazil	7	93
8 EU and EFTA	63	37
9 Middle East	73	27
10 Botswana	77	23
11 South Africa	7	93
12 Rest of SACU	31	69
13 Malawi	3	97
14 Mozambique	21	79
15 Tanzania	24	76
16 Zambia	5	95
17 Zimbabwe	21	79
18 Rest of SADC	11	89
19 Madagascar	0	100
20 Uganda	45	55
21 Rest of Sub-Saharan Africa	67	33
22 Rest of world	59	41

Source: FAO (2006)

4.3 Projected adoption rates of GM maize by farmers in selected countries

The fact that the GTAP model is that it is a static one that estimates what-if scenarios provided all other factors remain constant, creates a dilemma in practice as the trade responses to policy changes are step-by-step processes that may take a few years to reach a new equilibrium. As the adoption rate of GM technology amongst maize producers is high and increasing in many countries, it would be wrong to assume that the GM maize adoption levels in the major maize exporting countries will remain constant during the period. Therefore, in order to improve the realism of the model's predictions, it was necessary to project the forward adoption rate of GM maize in these countries.

Studies on the time-path of technology adoption by farmers show that it follows an S-shaped curve (Aker *et al.,* 2005). Initially, when a new technology is introduced, the adoption will be hesitant and slow as every farmer first need to determine its economic advantages for him/her. This is followed by a period of increasing acceptance as the demonstration effect induces more and more farmers to accept it. Eventually, however, the adoption rate slows down as fewer farmers are left to adopt the technology. The adoption rate can obviously not be higher than 100%, at which level everyone has adopted the technology.

According to various experts in the South African maize seed industry, the ceiling of adoption of GM maize in SA could be around 70 percent with current single and stacked GM events. This ceiling will however change to near 100% if/when drought tolerant varieties are introduced.

With all this in mind, different mathematical models were fitted to the adoption rates of GM maize in South Africa, the USA and Argentina to see if appropriate adoption time-paths could be simulated. In all cases the best fit was achieved with a fourth-order polynomial, and in all cases the R-square values were very high, which means that the model fitted the data very well. The advantage of the fourth-order polynomial is that it does project a saturation level, and as such it is in line with the theory on the adoption of technology. However, the fourth-order polynomial also has the disadvantage that it forces a downturn after the saturation level rather than a levelling-out situation, and this means that the model is more useful to estimate the saturation levels than the further adoption rates. In addition, it must be borne in mind that the model assumes that all other factors remain constant which is obviously not correct as the seed industry is continually developing newer and better GM varieties, and the saturation levels may eventually be higher than what the model indicates.

Figures 4.1 to 4.3 show the projected adoption rates of GM maize by farmers in the USA, Argentina and South Africa until the 2009/10 year.

In the case of the USA the model shows an exhaustion rate of nearly 70% in 2008/09. The data shows that the adoption had decreased from 1999/2000 to 2000/01 with not much of a recovery in 2001/02. According to James (2006), this was because farmers had believed that the infestation of insects would be low in 1999/2000 and 2000/01. After 2001, though, the adoption rate increased. Currently the rate is 61% and had it not been for the decrease in 1999/00, it may well have been notably higher. For the purpose of this study, it is assumed that the adoption rate of GM maize will eventually increase to 70%.

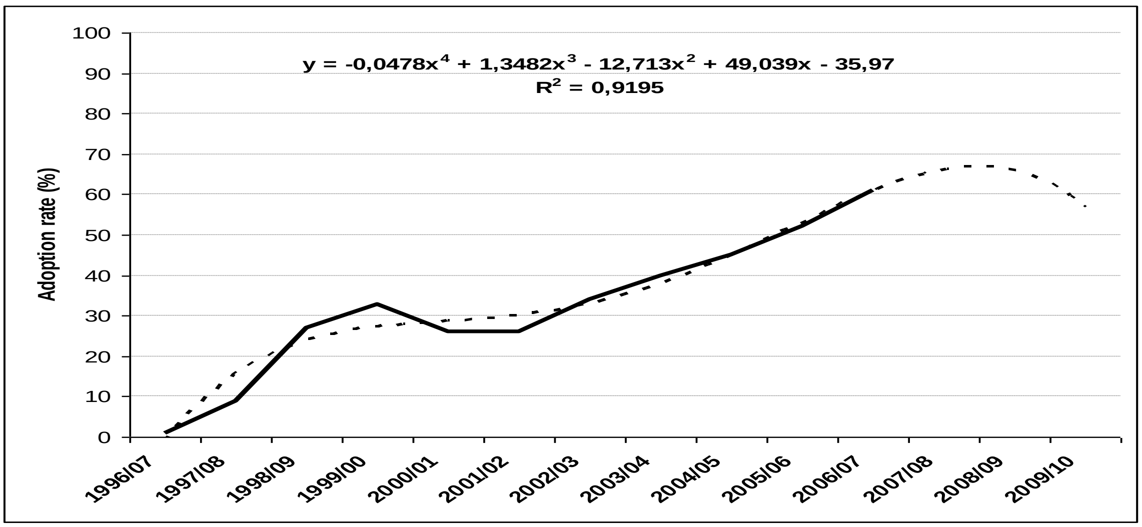

Figure 4.1: The projected adoption rate of GM technology by maize farmers in the USA

In the case of Argentina the saturation level with existing GM events is also indicated as near 70%. However, the adoption rate of GM soybeans is currently around 90%, and with the further improvement of GM maize varieties the adoption rate could well increase further. For the purpose of this study, it is assumed that the adoption rate of GM maize will, as in the USA, eventually increase to 80%.

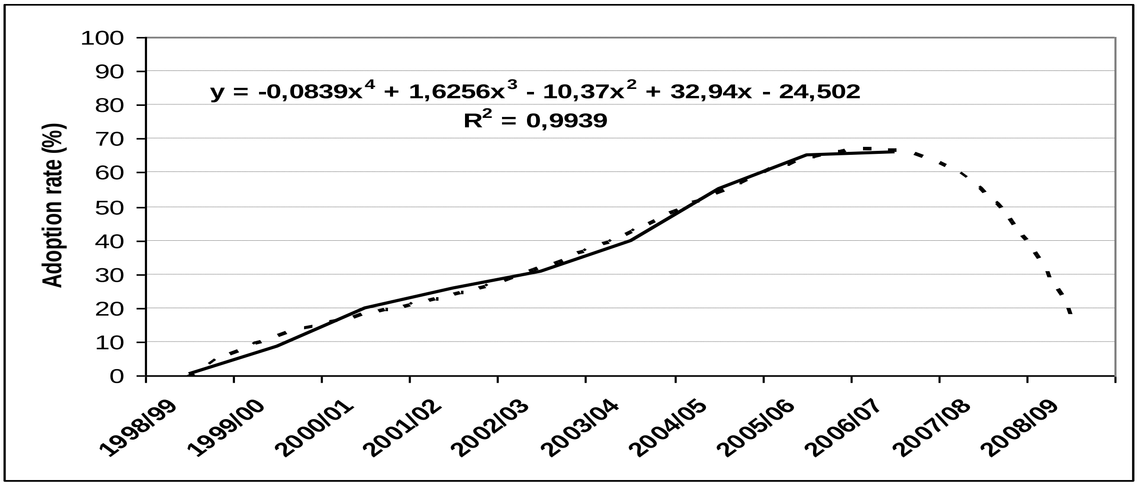

Figure 4.2: **The projected adoption rate of GM technology by maize farmers in Argentina**

In the case of South Africa, the current GM maize adoption rate is 46% and the indicated saturation rate is around 75%, which is commensurate with the saturation level indicated by the industry, as discussed in Section 3.3. For the purpose of this study, it is assumed that the adoption rate of GM maize will in the foreseeable future reach a level of 70%.

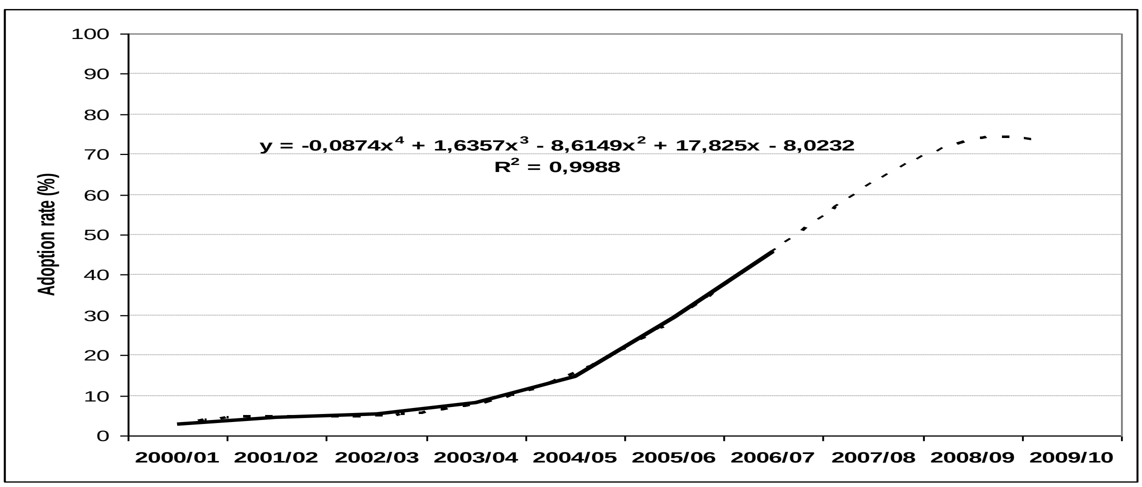

Figure 4.3: **The projected adoption rate of GM technology by maize farmers in South Africa**

SECTION 5

WHAT-IF SCENARIOS AND THEIR OUTCOMES

5.1 Basic assumptions

From the foregoing discussions, the following assumptions have been drawn as basic inputs into the various scenarios for GTAP model:

- Except where specifically stated, all other factors always remain constant; thus, if the result of a specific "shock" to the model's equilibrium would for instance show that prices will increase by X%, it does not mean that the prices had indeed increased by that percentage, but that the prices would have increased by that percentage if, and only if, all other factors had remained constant.

- The average yield advantage of GM maize cultivars over non-GM cultivars is on average 10% and this holds for South Africa as well as for the major maize exporting countries.

- The current (2006/07) GM maize adoption rates of 61% and 66% in the USA and Argentina respectively will increase in the foreseeable future to 80% in both countries. In South Africa the rate will increase from 46% to 70%, and in China and Brazil the rates will increase from nil to 40% and 25%, respectively.

- The current (2006/07) average cost of segregation and identity preservation (SIP costs) for non-GM maize in South Africa is R40 per ton and will increase to R100 per ton in the foreseeable future as the farmers' adoption of GM maize increases to 70%. The SIP cost in the base year of the model (i.e. 2001) is assumed to have been nil.

5.2 What-if scenarios

In order to estimate the outcomes of various policy decisions, "what-if" scenarios can be constructed and introduced into the GTAP model as "shocks" to the state of equilibrium in the model's database. The outcomes of the scenarios are then measured by the changes in the elements of the database after a new state of equilibrium is reached. For the purpose of this study, eight scenarios were constructed, namely:

Scenario 1: Baseline scenario

This scenario was constructed to estimate the extent to which the GM maize developments and regulations to date have advantaged or disadvantaged the South African maize industry and the country as a whole. It simulates the current world GM maize situation with the USA and Argentina respectively planting 61% and 66% of their maize areas to GM varieties, while South Africa plants 46% of its maize area to GM varieties. It was assumed that GM maize cultivars have on average a 10% yield advantage over non-GM cultivars in all of these countries, whilst the average SIP cost of non-GM maize was R40 per ton. As this scenario encompasses all the GM maize policy decisions and developments to date, it forms the basis against which the impact of all other scenarios is to be compared.

Scenario 2: Continued adoption

This scenario was constructed to answer the question: What would the effect be if South Africa continues to approve new GM events for general release? The scenario assumes that the GM maize adoption rate by farmers will increase to 80% in the USA and in Argentina, to 70% in South Africa, to 40% in China and to 25% in Brazil. It also assumes that the average SIP cost of non-GM maize increases to R100 per ton in South Africa as the higher GM maize adoption rate makes it increasingly expensive to source non-GM maize.

Scenario 3: SA consumers reject GM maize food products

This scenario was constructed to answer the question: What would the effect be if the South African food consumers would suddenly decide to reject all GM maize based food products whilst the feed industry continues to use GM maize? The scenario assumes that the South African maize farmers then will revert back to non-GM white maize cultivars but will continue to plant GM yellow maize cultivars, with the net effect an overall GM maize adoption rate of 48% (based on the food and feed share of the total domestic demand for maize). It is further assumed that the SIP cost of non-GM maize will stay at the current R40 per ton, and that the adoption rate of GM maize in USA, Argentina, China and Brazil will continue to increase to 80%, 80%, 40% and 25%, respectively.

Scenario 4: SA authorities ban the commercial importation of maize

This scenario was constructed to answer the question: What would the effect be if the South African authorities would ban the importation of all maize for commercial consumption? The purpose of this scenario is to test the extreme situation in which, for instance, the farmers in the major maize exporting countries adopt new GM maize events that cannot be approved in South Africa for commodity clearance, and where this adoption becomes so extensive that it becomes impossible to certify export consignments to be free of such events. In this scenario it is assumed that the authorities continue to permit the domestic production of GM maize and allow the introduction of new events into the domestic cultivars. It is further assumed that, as in Scenario 2, the GM maize adoption rate by farmers will increase to 80% in the USA and Argentina, to 70% in South Africa, to 40% in China and to 25% in Brazil. It also assumes that the average SIP cost of non-GM maize will increase to R100 per ton in South Africa.

Scenario 5: SA authorities ban maize imports from the USA

This scenario was constructed to answer the question: What would the effect be if it would become impossible to import maize from the USA? Although this scenario is again an unlikely one, it is less extreme than Scenario 4 in that it could conceivably become a reality if the USA, as the foremost developer of GM maize events, would approve events that are not approved in other major exporting countries and if, at the same time, it would become impossible to certify that an export consignment does not contain GM maize events that have not been approved in South Africa for general release or commodity clearance. In this scenario it is again assumed that the GM maize adoption rate by farmers will increase to 80% in the USA and Argentina, to 70% in South Africa, to 40% in China and to 25% in Brazil. It also assumes that the average SIP cost of non-GM maize will increase to R100 per ton in South Africa.

Scenario 6: SA authorities cease to approve new GM events for general release

This scenario was constructed to answer the question: What would the effect be if the South African authorities would cease to approve new GM maize events for general release but continue to approve new events for commodity clearance? In this scenario the domestic maize farmers will be deprived of the advantages of new GM maize technology whilst the domestic consumers will continue to have access to relatively cheap maize imports. It was assumed that in such a situation the domestic farmer adoption of GM maize will remain at 46% whilst the adoption rate will increase to 80% in the USA and Argentina, to 40% in China and to 25% in Brazil. It was also assumed that the average SIP cost of non-GM maize in South Africa will in such a scenario remain at R40.

Scenario 7: General acceptance of GM maize in South Africa

This scenario was constructed to answer the question: What would the effect be if food consumers in South Africa would fully accept GM maize based foods and beer, i.e. there would be no domestic demand for non-GM maize? In this scenario it was assumed that the GM maize adoption rate of the South African farmers will increase to 90%, the domestic non-GM SIP cost will increase to R100 per ton, and that farmer adoption rates of GM maize will increase to 80% in the USA and Argentina, to 40% in China and to 25% in Brazil. All non-GM maize in South Africa will at that stage be stored in silo bags.

Scenario 8: No maize exports to SADC countries

This scenario was constructed to answer the question: What would the effect be if for whatever reason it would become impossible to export South African maize to the rest of the SADC countries? This scenario is again an extreme one to consider a situation in which for instance the whole domestic maize crop would be adventitiously contaminated because of a high rate of GM maize adoption by domestic farmers whilst the SADC countries adopt very strict anti-GM regimes. In this scenario it was assumed that, as in Scenario 2, the GM maize adoption rate by farmers will increase to 80% in the USA and Argentina, to 70% in South Africa, to 40% in China and to 25% in Brazil. It also assumes that the average SIP cost of non-GM maize will increase to R100 per ton in South Africa.

5.3 Outcomes of the scenarios

The outcomes of the scenarios are shown in Table 5.1. In this regard it must be noted firstly that the model does not express an opinion on the allocation of advantages/disadvantages between the producers and consumers of any product and it is therefore not possible to say to which extent the scenarios will be to the advantage or disadvantage of the domestic maize producers or consumers. Secondly, as the model assumes that all other factors remain constant, the calculated changes resemble inherent changes as opposed to the changes that have actually happened.

Scenario 1: Baseline scenario

The GM maize developments and regulations to date have indeed advantaged the country as a whole. It has inherently gained a net welfare benefit of US $11,42 million, which was due to the fact that the higher technical efficiency of the GM maize cultivars released resources from the production of maize to the other sectors of the economy. This benefit would have been significantly higher had it not been for the increase in the SIP cost of non-GM maize from zero to R40 per ton.

As far as the maize industry is concerned, the fewer resources now employed in the production of maize have led to an inherent decrease of 0,09% in the production of maize, a decrease of 2,79% in the domestic price of maize, and a decrease of 7,12% in the import parity price of maize. Maize imports increased inherently by 5,92% and exports decreased by 1,41%. The decrease in the import parity price of maize is due to an increase in the GM maize adoption rates in the USA and Argentina.

Scenario 2: Continued adoption

If the South African authorities would from now on continue to approve new GM events for general release, the total welfare of the country as a whole will increase by a further US $5,4 million over the next few years. This further increase will be due to the higher technical efficiency of the GM maize cultivars, but will again be somewhat offset by the further increase in the SIP cost of non-GM maize.

The impact on the maize industry itself will however be relatively small. The international competitiveness of South African maize will increase because the adoption of GM maize technology by South African farmers increased more in the USA and Argentina. The continued adoption of GM maize will increase the domestic production of maize by 0,13% whilst the domestic price of maize will decrease by 1,33%. The import parity price of maize will decrease by 1,23% because of the higher GM adoption in the major exporting countries, but as this decrease is less than the decrease in the domestic price of maize, maize imports will decrease by 0,83%. Maize exports will increase by 0,27%.

Scenario 3: SA consumers reject GM maize food products

If the South African food consumers would suddenly decide to reject all GM maize based food products whilst the feed industry continues to use GM maize, the effect on the country and the maize industry will be quite small. The total national welfare will increase marginally by US $1,08 million from the current situation because the SIP cost of non-GM white maize will reduce from R40 per ton to nil. The economy will also gain a small advantage in technical efficiency as the overall GM maize adoption rate increases from the current 46% to 48% (all yellow maize) instead of to 70% (as in Scenario 2).

For the maize industry itself, the import parity price of maize will decrease by 1,22% as the continued adoption of GM maize in the major exporting countries increase the world supply of maize. The competitiveness of South African maize on the world market will decrease as the domestic producers revert back to non-GM white maize and thus suffer a technological disadvantage to the producers in the major maize exporting countries. The domestic price of maize will decrease by 0,32% and the domestic production of maize will decrease marginally by 0,17%. Maize imports will increase by 0,36% and exports will decrease by 1,39%.

Scenario 4: SA authorities ban the commercial importation of all maize

If the South African authorities would ban the commercial importation of all maize but continue to allow the introduction of new events into the domestic cultivars, the effect will be relatively drastic. The total national welfare will decrease by US $46,53 million from the current situation. The main cause of this decrease is a loss in the technical efficiency of the non-maize sectors of the economy which, in turn, is caused by a decrease in the overall availability of maize to them as intermediary inputs. However, the decrease is added to by the increase in the SIP cost of non-GM maize from R40 per ton to R100 per ton.

For the domestic maize industry itself, the domestic production of maize will increase by 6,91%, the domestic price of maize will increase by 1,56%, and maize exports will decrease by 4,36%. No maize will of course be imported and the import parity price of maize becomes irrelevant.

Scenario 5: SA authorities ban maize imports from the USA

If it would become impossible to import maize from the USA, the effect on South Africa will be very small as Argentina is by far the major origin of South African yellow maize imports whilst white maize can still readily be sourced from China and Brazil. The calculated decrease in the national welfare of US $7,29 million stems solely from the increase in the SIP cost of non-GM maize from R40 to R100 per ton.

The major effect on the domestic maize industry will be a decrease of 3,57% in exports. This decrease is due to the estimated increase of 1,04% in the domestic price of maize against a decrease in the world price of maize (as reflected by the estimated decrease of 1,22% in the import parity price of maize).

Scenario 6: SA authorities cease to approve new GM events for general release

If the South African authorities would cease to approve new GM maize events for general release but continue to approve new events for commodity clearance, the effect on the country and the maize industry will again be quite small. The national welfare will decrease marginally by US $0,49 million from the current situation. The impact on the domestic maize industry will also be very small.

Scenario 7: General acceptance of GM maize in South Africa

If food consumers in South Africa would fully accept GM maize based foods and beer, the impact on the country as a whole and on the maize industry will be relatively significant. The national welfare will increase by US $32,68 million, which is due partly to a general increase in technical efficiency as the maize farmers increase their adoption of GM maize, and partly due to the fact that the SIP cost of non-GM maize will apply only to a 10% residual of the total maize crop.

The impact on the maize industry, and especially on the trade in maize, will be significant as maize imports will decrease by 6,42% and exports will increase by 8,73%. The domestic maize price will decrease by 6,05% but, because of the higher productivity of the GM cultivars, the farmers will still afford to increase the production of maize by 1,6%.

Scenario 8: No maize exports to SADC countries

In this scenario, where it becomes impossible to export South African maize to the rest of the SADC countries, the model shows unexpected results. According to the model, the national welfare will increase by US $13,57 million, which is contrary to economic theory and logic. On closer inspection, the model showed that this increase will be caused mainly by a large increase in the exports of rice and sugar from the SADC countries to South Arica, which is even more contrary to reality. The probable reason for this inconsistency is that, like in the case of South Africa, the information for these countries in the model's database is incorrect and needs to be corrected before conclusions can be made with confidence.

Despite these inconsistencies, though, the results of the model do make sense as far as the domestic maize industry itself is concerned. With all other factors being constant, the maize exports will decrease by 56,44% and this will eventually result in a decrease of 7,16% in the domestic production of maize. This implies that South Africa should make a concerted effort to assist the rest of the SADC member countries to develop and implement sound biosafety policies and regulations according to the provisions of the Cartagena Protocol on Biosafety.

Table 5.1: Outcomes of the scenarios on the South African welfare and on the maize industry

	Scen. 1	Scen. 2	Scen. 3	Scen. 4	Scen. 5	Scen. 6	Scen. 7	Scen. 8
	Change from base year	Change from Scenario 1						
Change in:								
Total national welfare (US $ million)	11,42	5,40	1,08	-46,53	-7,29	-0,49	32,68	13,57
Maize production (%)	-0,09	0,13	-0,17	6,91	-0,51	-0,21	1,60	-7,16
Maize imports (%)	5,92	-0,83	0,36	-100,00	-1,34	0,67	-6,42	-1,75
Maize exports (%)	-1,41	0,27	-1,39	-4,36	-3,57	-1,56	8,73	-56,44
Maize price (domestic) (%)	-2,79	-1,33	-0,32	1,56	1,04	-0,02	-6,05	-1,85
Maize price (import parity) (%)	-7,12	-1,23	-1,22	*	-1,22	-1,16	-1,23	-1,22

SECTION 6

CONCLUSIONS AND RECOMMENDATIONS

The overall objective of the research was to estimate the potential impacts of GM maize on the South African maize trade. The study also addressed a number of secondary objectives to serve as inputs into the achievement of the main objective, namely:

- To describe and analyse elements of the international GM maize situation that could influence to South African trade in GM maize;
- to describe and analyse the GM maize situation within South Africa;
- to analyse the GM maize related developments in the export demand for South African maize; and
- to develop specific maize trade related scenarios to be analysed through an adjusted GTAP model.

The advent of the GM technology and the rapid adoption thereof by the producers of maize have inherently increased the world supply of maize and thereby depressed the world price of maize. The GTAP model showed that this, in turn, decreased the import parity price of maize in South Africa by more than 7%, which was something the domestic producers couldn't avoid and had to adjust to. This raised the question of how the domestic producers adjusted to it and what the effect on the rest of the industry was..

The model estimates that, in comparison to 2001, South African maize imports in 2006 were inherently nearly 6% more whilst the exports of maize were inherently around 1,4% less. The increased imported competition depressed the domestic price of maize by nearly 3%, but despite this the domestic production of maize remained inherently unchanged. This continued production is fully ascribed to the fact that the maize producers, too, had access to GM maize cultivars and that the (average) yield advantages of the GM maize cultivars enabled the producers to increase their productive efficiency to meet the imported competition. The domestic consumers of maize have obviously benefited from the lower import parity and domestic prices of maize. It can therefore be concluded with confidence that the advent of the GM technology has significantly advantaged the domestic consumers of maize. For the country as a whole, the cheaper imports and the higher overall productive efficiency led to a net increase in the national welfare of more than US $11 million.

Following this analysis, the next question was how future developments in the GM maize arena will affect the South African maize industry. In order to answer this, clarity had to be found on a number of secondary issues. In this regard, the study led to the following conclusions:

(1) The genetic modification of plants is here to stay and the technology will continue to be developed and adopted. It has notable yield advantages over non-GM cultivars and enables producers to use less pesticides and herbicides. One the one hand, the GM technology is an increasingly important tool in the world's continuous challenge to produce a sufficient supply of affordable grains. At the same time, the resultant decrease in the use of chemicals assist the world to maintain the environment.

(2) On the demand side, the technology has raised concerns on the biosafety thereof. Many countries have adopted stringent biosafety regulations that were seen as a new form of non-tariff barriers to trade. These issues were referred to two international bodies, namely the Codex Alimentarius and the Cartagena Protocol on Biosafety. The agreements that these bodies are striving to achieve on GM issues are however still evolving and are at this stage still leaving a number of loopholes for trade abuses. The World Trade Organisation has recently, for the first time, become involved in the arbitration of a GM related grain trade dispute. However, the result showed that countries seemingly can, if they want to, circumvent WTO obligations by changing their GM regimes from import restrictions to labelling and traceability regulations

(3) The farmers in the world’s two largest exporters of maize, namely the USA and Argentina, could soon reach GM maize adoption rates of more than 70%, in which case it will be difficult to procure non-GM maize from them, especially if the consignments to be tested on arrival in the importing countries. In the world’s two next largest maize exporters, namely China and Brazil, GM maize cultivars will soon be available to farmers and the adoption thereof will be rapid, which means that premiums for non-GM maize from these two countries will gradually increase.

(4) In the world’s two largest importers of maize, namely Japan and Korea, the food and starch industries will most likely continue to demand non-GM maize for the foreseeable future. They will also continue to pay the premiums necessary to originate the non-GM maize, although they could perhaps gradually relax some of the threshold levels in their labelling regulations if it becomes increasingly difficult or expensive to source non-GM maize. The feed industries in these countries, though, will continue to import maize from the cheapest source. In Mexico, the importation of GM maize for both the food and feed industries will probably not be restricted, whilst the domestic production of GM maize will probably not be approved for the foreseeable future. In Taiwan, maize imports for the feed industry will continue to be GM, but the food consumers of maize based products could perhaps gradually swing to non-GM maize products. In summary, it is not expected that the developments in the GM regimes in these countries will for the foreseeable future cause any significant changes in the world maize trade patterns.

(5) Although the European Union (EU) is only the fifth major maize importing country, its GM maize regime does seem to have a strong effect on similar regimes in other countries. Although the EU’s GM labelling is very restrictive, it seems as though some wavering is starting to develop. However, the food retailers are still very strongly against GM foods and it is most likely that the EU’s food demand will stay non-GM for quite some time to come.

(6) South Africa has a comprehensive and mature GM regime. The GM legislation and regulations are largely cautious but not restrictive, although recently there have been some questions on the way forward. As new GM maize events are approved for general release and new cultivars are developed, the GM maize adoption by South African farmers will most likely continue to increase to a saturation level of around 70% of the total area planted to maize. However, if (the expected) drought tolerant events are successfully developed and become available, the adoption will escalate very rapidly to virtually 100%. On the domestic demand side, there is no notable resistance to GM maize based food products and the labelling regulations are not restrictive as only such products that are "significantly different" from the non-GM food products have to be labelled as such. Only one of the major food retailing groups insists on labelling GM food products, but these labels are not obtrusive and has to date not had any notable effect on the consumption of the products. The industrial processors of maize do demand non-GM maize, but this demand is based on concerns that the domestic food consumers may at some stage be incited to reject GM based foods and will most likely be relaxed as the processors are persuaded that the majority of the consumers have in fact accepted GM food products as safe (e.g. as in the USA). This demand also seems to be premium sensitive and may be amended as premiums for non-GM maize increase.

(7) South Africa could inadvertently be importing and releasing into the environment GM maize events that are not approved for general release. As the adoption of GM technology in maize exporting countries increase, the danger of commingling different maize varieties and GM events will increase. It could increasingly happen that consignments of maize that are certified as containing only approved events may on retest prove different due to the problems associated with sampling.

(8) The Sub-Saharan African countries, which are the main export destinations of South African maize, do currently not allow the importation or domestic production

of GM maize. Most of the countries are however in process of developing their GM regimes and will probably become more GM friendly in the near future. Most of them allow the importation of GM maize in milled form, which means that their GM concerns are environmental rather than health or consumer resistance, and as they develop their GM legislation and regulations they will start to approve GM events for general release. The notable exception in this regard is Zambia that seems to have some market advantage objectives in its GM approach.

With these conclusions as background, the GTAP model shows that policy measures that will restrict the country's access to new GM maize events will disadvantage both the domestic producers and consumers of maize. The consumers will suffer a decrease in total welfare whilst the producers will be disadvantaged in terms of imported competition. The model shows that, more specifically:

(i) The continued approval and domestic adoption of new GM maize events will be in the best interest of the country; the world's continued adoption of GM technology will depress world prices and increase import competition for South African maize producers, and their best remedy is to have access to the same technology;

(ii) If the domestic consumers would totally reject GM maize based food products, the effect on both the country and the maize industry will not be very significant as the resultant loss in technical efficiency on the production side of the economy will be compensated for by much lower costs to segregate and identity preserve (SIP costs) non-GM maize; the farmers no longer plant GM white maize but will continue to plant GM yellow maize whilst the feed industry does not require non-GM maize;

(iii) If the domestic consumers would, however, fully accept GM maize based foods and beer, the impact on the country as a whole and on the maize industry will be significantly beneficial, especially as the total SIP cost in the economy will virtually disappear and the domestic price and imports of maize will decrease; and

(iv) It is important for the South African maize industry to maintain and increase maize exports to the SADC countries; if this demand should fall away, the domestic production of maize could drop by more than 7%.

Resulting from the study, the following recommendations are pertinent:

(i) Because the world swing to GM maize will inherently depress the world price of maize, the South African GM authorities should continue to approve new GM maize events for general release, and commodity clearance before general release should be the exception rather than the rule;

(ii) The South African maize industry should make concerted efforts to persuade the domestic consumers of the food safety of GM maize based foods;

(iii) The South African authorities and maize industry should assist the other SADC member countries to develop and adopt proper GM policies and regulations;

(iv) The South African GM authorities should compel all maize imports to be retested for the presence of GMO's on arrival before permitting the cargoes to be discharged; and, finally,

(v) It is recommended that trade flows between countries should be scrutinised in detail to check for the correctness of actual flows. This would entail a proper evaluation of the base data of the GTAP model specific to countries playing a relatively smaller role in the international trade of agricultural products.

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