The Production and Price Impact of Biotech Crops

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Abstract

Biotech crops have now been grown commercially on a substantial global scale since 1996. This paper examines the production effects of the technology and impacts on cereal and oilseed markets through the use of agricultural commodity models. It analyses the impacts on global production, consumption, trade and prices in the soybean, canola and corn sectors. The analysis suggests that world prices of corn, soybeans and canola would probably be, respectively, 5.8%, 9.6% and 3.8% higher, on average, than 2007 baseline levels if this technology was no longer available to farmers. Prices of key derivatives of soybeans (meal and oil) would also be between 5% and 9% higher, with rapeseed meal and oil prices being about 4% higher than baseline levels. World prices of related cereals and oilseeds would also be expected to be higher by 3% to 4%.

The effect of no longer using the current widely used biotech traits in the corn, soybean and canola sectors would probably impact negatively on both the global supply and utilization of these crops, their derivatives and related markets for grain and oilseeds. The modelling suggests that average global yields would fall for corn, soybeans and canola and despite some likely "compensating" additional plantings of these three crops, there would be a net fall in global production of the three crops of 14 million tonnes. Global trade and consumption of these crops/derivatives would also be expected to fall. The production and consumption of other grains such as wheat, barley and sorghum and oilseeds, notably sunflower, would also be affected. Overall, net production of grains and oilseeds (and derivatives) would fall by 17.7 million tonnes and global consumption would fall by 15.4 million tonnes. The cost of consumption would also increase by $20 billion (3.6%) relative to the total cost of consumption of the (higher) biotech-inclusive level of world consumption. The impacts identified in this analysis are, however, probably conservative, reflecting the limitations of the methodology used. In particular, the limited research conducted to date into the impact of the cost-reducing effect of biotechnology (notably in herbicide-tolerant soybeans) on prices suggests that the price effects identified in this paper represent only part of the total price impact of the technology.

Keywords: biotechnology, cereals, crop yields, oilseeds, price effects, productivity.

1 Introduction

Biotechnology crop traits have been applied on a widespread commercial global basis since 1996. In 2008, the global cultivation area of biotech crops reached 125 million hectares, a 74-fold increase from the level in 1996. The number of countries adopting biotech crop cultivation has also increased from 6 in 1996 to 25 in 2008, with the United States leading the way in the utilization of biotechnology in crop production. The rapid growth of biotech crop hectares between 1996 and 2008 has made biotech crops the most rapidly adopted crop technology in agriculture over this period (James, 2008). The increasing number of biotech crop hectares and adopting countries are likely driven by the growing concern for food security, biodiversity, and agricultural environmental footprint.

Currently, the biotech crop hectares are primarily utilized for soybeans, corn, cotton and canola. The technology used so far has been agronomic, including cost-saving technology delivering herbicide tolerance in all four of these crops, and insect resistance in corn and cotton. This technology has provided farmers with productivity improvements through a combination of yield improvements and cost reductions. As such, the technology has had an impact on the prices of soybeans, corn, cotton, and canola (and their derivatives) both in the countries where biotech traits were applied and in the global market. However, assessing the impact of the biotechnology application on the prices of these crops and their derivatives is challenging since current and past prices reflect a multitude of factors including the introduction and adoption of biotechnologies. Previous studies have contributed to the literature by evaluating the impacts of biotechnology application for field crops on national/regional economy and farmers' welfare (e.g. Martin and Hyde 2001, Sobolevsky, Moshini, and Lapan 2005, Anderson, Valenzuela, and Jackson 2008). However, most of those studies primarily focused on a single crop, such as, corn, soybeans or cotton. Thus, the impact analysis of biotechnology adoption did not capture the responsiveness of the production of other crops. Furthermore, since the application of biotechnology usually occurs in various field crops, the joint impacts of biotechnology adoption on local and global agricultural markets need to be further explored.

Realizing the surging significance of biotechnology application in the U.S. and global crop markets, this paper summarizes the production impacts of biotech crops[1] and presents the findings of analysis that has

[1] Drawing primarily on work by one of the authors: Brookes and Barfoot (2008). GM crops: global socio-economic and environmental impacts 1996-2006, *Agbioforum* 11, 1, 21-38. A more detailed paper is also available on www.pgeconomics.co.uk.

sought to quantify the impact of the use of biotech traits on usage and the prices of corn, soybeans and canola and their main derivatives.[2]

2 Methodology

The approach used to estimate the impacts of biotech crops on usage, trade and prices of the four crops and their derivatives has been to draw on part of a broad modelling system of the world agricultural economy comprised of US and international multi-market, partial-equilibrium models of production, use and trade in key agricultural commodities.[3] The models cover major temperate crops, sugar, ethanol and biodiesel, dairy, and livestock and meat products for all major producing and consuming countries and calibrated on most recently available data. Extensive market linkages exist in these models, reflecting derived demand for feed in livestock and dairy sectors, competition for land in production, and consumer substitution possibilities for close substitutes such as vegetable oils and meat types. The models capture the biological, technical, and economic relationships among key variables within a particular commodity and across commodities. They are based on historical data analysis, current academic research, and a reliance on accepted economic, agronomic, and biological relationships in agricultural production and markets. There is a link between the US and international models, which is made through prices and net trade equations. The models are used to establish ten-year commodity projections for a baseline and for policy analysis, and are used extensively for the market outlook and policy analysis.

In general, for each commodity sector, the economic relationship that supply equals demand is maintained by determining a market-clearing price for the commodity. In countries where domestic prices are not solved endogenously, these prices are modelled as a function of the world price using a price transmission equation. Since the models for each sector can be linked, changes in one commodity sector will impact other sectors. For this particular study, the US Crops, International Grains, International Oilseed, International Sugar, and International Bio-fuels models were used.

In terms of the structure of the models, the following identity is satisfied for each country/region and the world:

$$\text{Beginning Stock} + \text{Production} + \text{Imports} = \text{Ending Stock} + \text{Consumption} + \text{Exports} \quad (1)$$

Production is divided into yield and area equations, while consumption is divided into feed and non-feed demand. The models include behavioural equations for area harvested, yield, crop production on the

[2] The impact of biotech traits in the cotton sector are not included in the analysis

[3] More details about the modelling structure are presented in Appendix 1.

supply side, and per capita consumption and ending stocks on the demand side. Equilibrium prices, quantities, and net trade are determined by equating excess supply and excess demand across countries and regions.

More specifically, in terms of acreage, harvested area is expressed as a function of own and competing crop prices in real terms, as well as lagged harvested area and prices. Prices enter area functions either as part of real gross returns per unit of land (price multiplied by yield) or merely as prices depending on the particular commodity model. The US model, because of extensive data availability, is divided into nine regions. The planted area for each crop within each region depends on expected net returns, which include real variable production expenses per unit of land, for the crop and competing crops.

To satisfy the identity in equation (1), two different methods are used. In most of the countries, domestic price is modelled as a function of the world price with a price transmission equation, and the identity is satisfied with one of the variables set as the residual. In other cases, prices are solved to satisfy the identity.

Agricultural and trade policies in each country are included in the models to the extent that they affect the supply and demand decisions of the economic agents. The models assume that the existing agricultural and trade policy variables will remain unchanged in the outlook period. Macroeconomic variables, such as GDP, population, and exchange rates, are exogenous variables that drive the projections of the model. All models are calibrated on 2007/08 marketing year data for crops, and ten-year annual projections for supply and utilization of commodities and prices for the US and the world are generated for the period between 2008 and 2017. Elasticity values for supply and demand responses are based on econometric analysis and on consensus estimates. Elasticity parameters estimates and policy variables are available at http://www.fapri.iastate.edu/tools/.

Data for commodity supply and utilization are obtained from the FO Lichts online database, the Food and Agriculture Organization (FAO) of the United Nations (FAOSTAT Online, 2006), the Production, Supply and Distribution View (PS&D) of the US Department of Agriculture (USDA), and the European Commission Directorate General for Energy and Transport, the ANFAVEA (2005) and UNICA (2006). Supply and utilization data include production, consumption, net trade and stocks. The macroeconomic data are gathered from the International Monetary Fund and Global Insight.

The empirical analysis relies on these agricultural commodity models of the main regions of the world (e.g., North & South America, the EU-27, etc.) to estimate the impact on national, regional and world

markets and prices for cereals and oilseeds. These models have been developed to allow for forward-looking projections (over a ten-year period) to be made relating to production, use, trade and prices of key commodities. The models are not directly able to estimate the impact of the technology on past prices (of corn, soybeans and canola and their key derivatives). One advantage of these models is that it is possible to establish a baseline and then remove the impact of biotechnology on yields. This allows the isolation of the impact on prices and usage due to biotech crops and not due to other factors such as macroeconomic and weather variables. However, the models *do not* allow for estimating the impact on crop prices arising from changes to the cost base of crop production (a major impact of herbicide tolerant technology). Some (limited) economic analysis has previously been undertaken to estimate the impact of biotechnology-induced cost of production changes, notably on the global prices of soybeans. Moschini et al. (2000) estimated that by 2000 the influence of biotech soybean technology on world prices of soybeans had been between -0.5% and -1%, and that as adoption levels increased this could be expected to increase up to -6% (if all global production was biotech). Qaim and Traxler (2002, 2005) estimated the impact of GM HT soybean technology adoption on global soybean prices to have been -1.9% by 2001. Based on this analysis, they estimated that by 2005 it was likely that the world price of soybeans may have been lower by between 2% and 6% than it might otherwise have been in the absence of biotechnology. This benefit will have been dissipated through the post farm gate supply chain, with some of the gains having been passed onto consumers in the form of lower real prices. The authors of this paper, therefore, acknowledge this failure to include the potential impact of biotechnology on costs of production and prices as a limitation of the research, which potentially underestimates the impact of the technology on prices. In addition, the analysis uses 2007 as the baseline against which the analysis is run. This therefore assumes that the level of biotech trait adoption in 2007 represents the 'counterfactual situation'. This is unlikely to fully represent the counterfactual situation over the period examined by the model, and therefore represents an additional weakness of the analysis.

Yield and production change assumptions for the impact of biotech crops were used as bases for analysis in the models by projecting forward a 'what if' scenario in which the currently used biotech traits were no longer available. The yield and production change assumptions used were those identified in the published work of Brookes and Barfoot (2008).[4] For example, insect resistant corn technology in the US has delivered an average 5% improvement in corn yields. The Brookes and Barfoot analysis is itself based on a literature review of impacts of biotechnology traits globally since 1996, and details of the specific country and trait-specific studies used can be found in the references section of this paper. To analyse the

[4] www.pgeconomics.co.uk and in *Agbioforum* (2008) 11, 1, 21-38 www.agbioforum.org. The specific yield impacts used derive from Appendix 2 of the *Agbioforum* paper.

impact of this yield improvement, first a baseline is established (starting in 2008, and for the next ten years covered by the model projections) with the trend growth rate of yield. Then a scenario is run where the yields were effectively lower than the baseline level (starting in 2008 and ending in 2017). The baseline represents the current status quo (technology used), and the scenario implies that the technology is no longer available. The difference between the baseline and scenario represents the impact of the technology (or more literally, the impact of no longer using the technology).

The models effectively assume the decreases in average crop (e.g., corn) yield in the countries using GM technology as a 'shock' change to the various regional parts of the models. This then calculates revised yield values, changes in production and consumption, changes in stocks, changes in imports and exports and changes in areas allocated to other crops. Knock-on effects on the price of each crop (corn, soybeans and canola) plus effects on other crop (e.g., wheat, barley, sunflower) were also derived, both at a regional, and a world level. Knock-on effects on derivatives of corn, soybeans and canola are also derived.

3 Production and yield assumptions

The production and yield change assumptions used in this analysis derive from the work of Brookes and Barfoot (2008), which itself draws on numerous crop and country-level impact studies. Section 3.1 below provides a summary of this data, and the assumptions used for the analysis are presented in section 3.2.

3.1 Production and yield impacts of biotech traits

3.1.1 Insect resistant (IR) corn impacts

Two biotech insect resistant traits have been commercially used targeting the common corn boring pests (*Ostrinia nubilalis* [European corn borer or ECB] and *Sesamia nonagroides* [Mediterranean stem borer or MSB] and corn rootworm pests, *Diabrotica*). These are major pests of corn crops in many parts of the world and significantly reduce yield and crop quality, unless crop protection practices are employed.

The two biotech IR corn traits have delivered positive yield impacts in all user countries when compared to average yields derived from crops using conventional technology (mostly application of insecticides and seed treatments) for control of corn boring and rootworm pests. The yield impact varies from an average of about +5% in North America to +24% in the Philippines (Table 1). In terms of additional production, on an area basis, this is in a range of +0.31 tonnes/ha to +0.72 tonnes/ha.

Average yield and production impact across the total area planted to biotech IR corn traits over the eleven-year period has been + 5.7% (+0.45 tonnes/ha). This has added 47 million tonnes to total corn production in the countries using the technology.

In 2006, the technology delivered an average of 0.47 tonnes/ha in extra production which was equal to an extra 9.7 million tonnes of corn production (Table 1).

Table 1: Corn: yield and production impact of IR traits 1996-2006

	Cumulative total corn area (ha)[5]	**Cumulative trait area (ha)**	**% of crop to trait[6]**	**Average trait impact on yield %[7]**	**Average yield impact (tonnes/ha)**	**Additional production from trait (tonnes)**
US corn borer resistant	351,842,503	81,016,473	23%	+5.0%	+0.45	36,078,447
US corn rootworm resistant	As above	6,596,520	1.9%	+5.0%	+0.45	3,130,130
Canada corn borer resistant	13,269,070	4,239,214	31.9%	+5.0%	+0.38	1,628,075
Canada corn rootworm resistant	As above	35,317	0.3%	+5.0%	+0.38	14,537
Argentina corn borer resistant	23,951,406	10,024,000	41.9%	+7.6%	+0.49	4,862,787
Philippines corn borer resistant	10,082,808	247,698	2.5%	+24.1%	+0.52	127,920
S Africa corn borer resistant	21,909,720	2,392,000	10.9%	+14.5%	+0.43	1,034,735
Uruguay corn borer resistant	184,000	100,000	54.3%	+6.1%	+0.31	30,559
Spain corn borer resistant	4,013,343	303,656	7.6%	+7.6%	+0.72	218,132
Cumulative totals	**425,252,850**	**104,954,778**	**24.7**	**+5.7%**	**+0.45**	**47,125,322**
2006	**41,751,216**	**20,640,503**	**49%**	**+6.7%**	**+0.47**	**9,734,898**

[5] For consistency purposes, the total areas presented refer only to the years in which the IR traits were used by farmers - from 1996 in the US and Canada, from 1998 in Spain and Argentina, from 2000 in South Africa, from 2003 in the Philippines and from 2004 in Uruguay. Corn rootworm resistant corn has also been available to US farmers from 2003 and to Canadian farmers from 2004.

[6] From year of first commercial planting to 2006.

[7] Average of impact over years of use, as used by Brookes and Barfoot (2008).

3.1.2 Herbicide tolerant (HT) soybeans

Weeds have traditionally been a significant problem for soybean farmers, causing important yield losses (from weed competition for light, nutrients and water). Most weeds in soybean crops have been reasonably well controlled, based on application of a mix of herbicides.

Although the primary impact of biotech herbicide tolerant (HT) technology has been to *provide more cost effective* (less expensive) and *easier* weed control versus improving yields from *better* weed control (relative to weed control obtained from conventional technology), improved weed control has, nevertheless occurred, delivering higher yields. Specifically, HT soybeans in Romania improved the average yield by over 30% (Figure 1).

Biotech HT soybeans have also facilitated the adoption of no tillage production systems, shortening the production cycle. This advantage enables many farmers in South America to plant a crop of soybeans immediately after a wheat crop in the same growing season. This second crop, additional to traditional soybean production, has added 53.1 million tonnes to soybean production in Argentina and Paraguay between 1996 and 2006. In 2006, the second crop soybean production in these countries was 11.6 million tonnes (Table 2).

Table 2: Second crop soybean production facilitated by biotech HT technology in South America 1996-2006 (million tonnes)

Country	Year first commercial use of HT soybean technology	Second crop soybean production from date of first commercial use to 2006
Argentina	1996	50.9
Paraguay	1999	2.2
Total		**53.1**

3.1.3 Herbicide tolerant (HT) canola

Weeds represent a significant problem for canola growers contributing to reduced yield and impairing quality by contamination (e.g., with wild mustard seeds). Conventional canola weed control is based on a mix of herbicides which has provided reasonable levels of control although some resistant weeds have developed (e.g., to the herbicide trifluralin). Canola is also sensitive to herbicide carryover from (herbicide) treatments in preceding crops which can affect yield.

The main impact of biotech HT canola technology, used widely by canola farmers in Canada and the US, has been to provide more cost effective (less expensive) and easier weed control, coupled with higher yields. The higher yields have arisen mainly from more effective levels of weed control than was

previously possible using conventional technology. Some farmers have also obtained yield gains from biotech derived improvements in the yield potential of some HT canola seed.

The average yield impacts have been about +6% (+0.1 tonnes/ha) in the US and about +10% (+0.15 tonnes/ha) in Canada (Figure 1). Over the 1996-2006 period, the additional North American canola production arising from the use of biotech HT technology was 3.2 million tonnes.

3.1.4 Herbicide tolerant (HT) corn

Weeds have also been a significant problem for corn farmers, causing important yield losses. Most weeds in these crops have been reasonably controlled based on application of a mix of herbicides. The HT technology used in corn has mainly provided more cost effective (less expensive) and easier weed control rather than improving yields from better weed control (relative to weed control levels obtained from conventional technology).

Improved weed control from use of the HT technology has, nevertheless, delivered higher yields in some regions (Figure 1). For example, in Argentina, where HT corn was first used commercially in 2005, the average yield effect has been +9%, adding +0.36 tonnes/ha to production. Similarly in the Philippines, (first used commercially in 2006), early adopters are finding an average of +15% to yields (+0.72 tonnes/ha).

Figure 1: Herbicide tolerant crops: yield and production impact of biotechnology 1996-2006 by country

3.2 Conversion of production and yield impacts into usable assumptions

To provide suitable assumptions for input into the agricultural commodity models, the production and yield impacts summarised in section 3.1, were converted into national level yield equivalents. These are

presented in Table 3. These yield change assumptions were then introduced into the models to identify impacts of withdrawing the (bio) technology from production systems and hence indirectly identify the impact of the biotech traits to date. The results are presented in section 4.

Table 3: Yield impact assumptions – to lower average yields for countries/crops assuming no biotech used from 2008 onwards

Crop	Average yield/production effect on biotech area 2006	% of crop to trait (2006)	Yield impact of technology related to average yield on total crop if no longer used
US Corn	+5%	49%	-2.45%
Canada corn	+5%	50%	-2.45%
Argentina corn	+7.6%	73%	- 5.55%
Philippines corn	+24.1%	4%	-0.97%
South Africa corn	+14.5%	35%	-5.1%
EU 27 corn	+6.1% (Spain)	15% of Spain 3.3 % of EU-27 area	-0.2% on EU-27 average yield
EU-27 soybeans	+31% (Romania)	26% of EU-27 area	-8.1%
Paraguay soybeans	+7.5% second crop	7.5%	-7.5%
Argentina soybeans	+20% second crop	20%	-20%
US canola	6%	98%	-5.9%
Canada canola	+3.7%	84%	-3.1%

4 Impact of biotech traits on prices, production, consumption and trade in the cereals and oilseeds sectors

4.1 World level

4.1.1 Prices

The running of the agricultural commodity models under the 'no biotech traits' scenario suggests that the impact that these productivity enhancing biotech traits in corn, soybeans and canola have had on world prices of both these crops/derivatives and other cereals and oilseeds is significant. We consider the no biotech scenario as a deviation from the 2007 baseline. In the scenario, the yield shocks are fully implemented in 2008 through 2017. We report the average of these annual changes for the years 2008 through 2010 as a summary indicator of the short term impacts. The scenario run shows that if these traits were no longer used in global agriculture, the loss of the yield and production enhancing capabilities of the technology would result in world prices of corn, soybeans and canola increasing by +5.8%, +9.6% and +3.8% respectively (Figure 2). There would also be knock-on effects on the prices of derivatives (e.g., a +9% increase in the world price of soymeal and a +5% increase in the price of soy oil) and other

cereals and oilseeds (e.g., increases in prices of +2.7% to +4.2% or wheat, barley and sorghum). In monetary ($) terms, Figure 3 shows the impacts of these price increases relative to the average 2007/08 world price levels.[8] Given the limitations of the analysis (in not including examination of the impact of the cost reducing impact of the technology), these estimates of impact on prices are probably understated. Additional information is presented in Appendices 2 and 3.

Figure 2: Increase in world commodity prices if biotech traits are no longer used

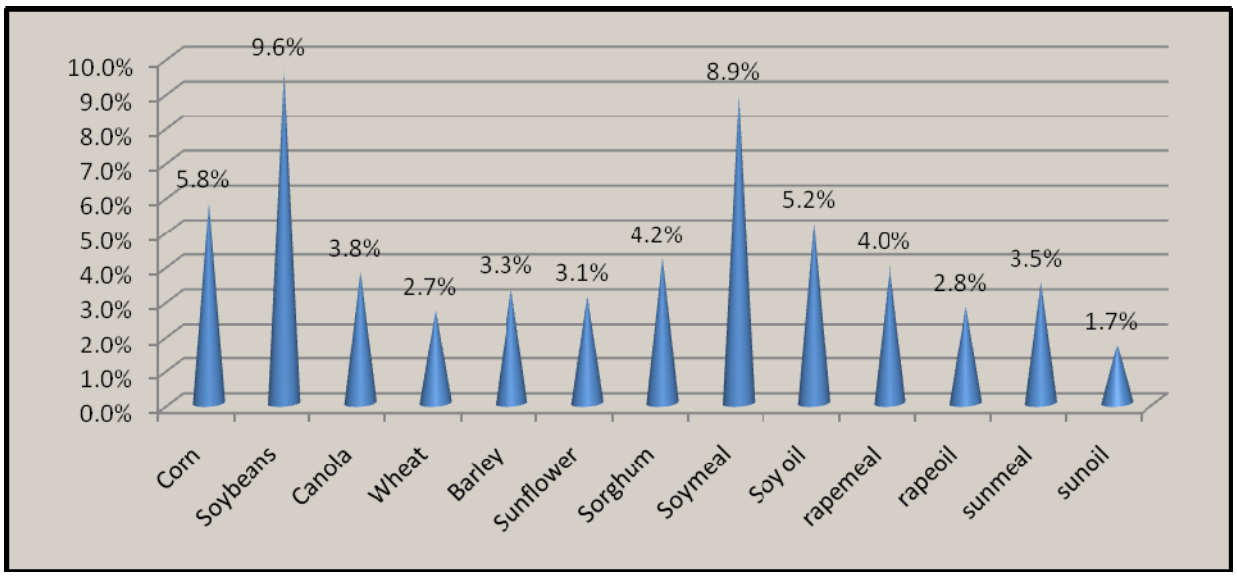
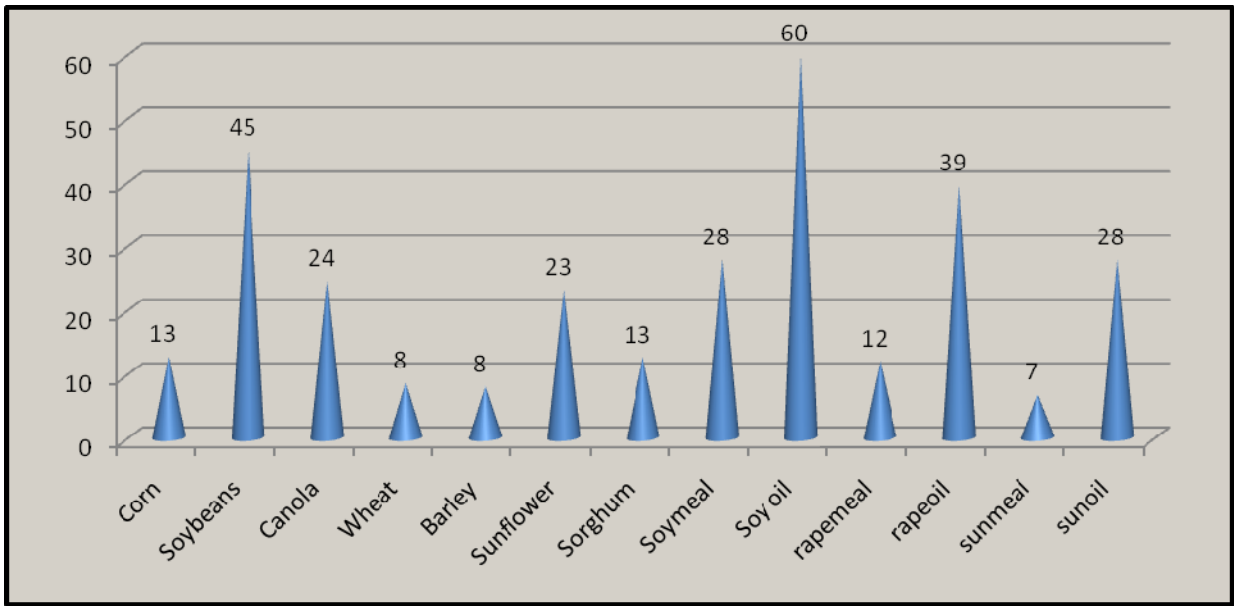


Figure 3: Increase in world commodity prices if biotech traits are no longer used ($/tonne)



[8] The impacts presented in Appendix 2 show the price increases relative to the baseline price levels (average of 2008 through 2010) and are therefore marginally different from the changes presented in Figure 3 which relate to actual 2007/08 average prices. Appendix 3 summarises the 2007/08 data used as the base for this figure

Relating these price changes to global consumption, this is equivalent to adding $25 billion (+4.5%) to the total cost of consumption of these crops/derivatives in 2007/08 (Table 4). The sectors most affected would be the corn and soybean/derivative using sectors, although there would also be a significant knock-on effect in the wheat sector.

Table 4: Global consumption of key commodities/derivatives 2007-08 and impact of price changes

	Consumption (million tonnes)	**Cost of consumption ($ billion)**	**Additional cost of consumption if biotech traits no longer available ($ billion)**
Corn	776.80	169.3	9.82
Wheat	618.10	194.1	5.24
Barley	136.30	33.0	1.09
Sorghum	63.28	18.9	0.79
Soy meal	157.09	49.3	4.39
Soy oil	37.40	43.1	2.24
Canola meal	27.12	8.1	0.32
Canola oil	18.34	25.9	0.72
Sunflower meal	10.43	2.0	0.07
Sunflower oil	9.41	15.4	0.26
Total	**1,854**	**559.1**	**24.94**

Sources: Baseline data from USDA Market & Trade reports. Prices based on import/export levels using mainstream ports of trade (source: USDA). These consumption figures (see Appendix 3) differ marginally from the consumption values used in the model baseline presented in Appendix 2.

In terms of income, it is important to recognise that the productivity enhancing technology has already had an impact on producer (farmer) incomes. The downward world price effects of the technology identified above represent a loss to farmer incomes but a gain to consumers. The negative price effects at the producer level have, though, been more than offset by the direct income gains associated with adoption of the technology for those farmers who have used biotech traits (the direct farm income gain identified from adoption of biotech traits over the period 1996-2006 was $33.8 billion [Brookes and Barfoot 2008]. This income gain was calculated net [inclusive] of the price effects identified above by using current farm level prices for each crop, country and year). In contrast, those farmers who have chosen not to adopt the technology or have been denied access to the technology (e.g., on political or regulatory grounds) have experienced the negative price effect but not gained from the yield gains and cost savings associated with using the technology.

4.1.2 Production, trade and consumption impacts

The effect of no longer using the current biotech traits in the corn, soybean and canola sectors will have an impact on both the supply and utilization of these crops, their derivatives, and related markets for grain and oilseeds.

By taking away the positive yield and production impacts of the technology from the areas planted to these traits, the negative impacts would be felt most in the current (technology) user countries (see section 3). At the global level, the model analysis suggests that the negative impacts on the yields of the three crops are equal to an average reduction of 1.5%, 4.3% and 0.65% respectively for corn, soybeans and canola (Table 5).

Table 5: Potential change to global production base if biotech traits are no longer used

	Area change (million ha)	Yield (tonnes/ha)	Production (million tonnes)
Corn	+0.48 (+0.3%)	-0.08 (-1.5%)	-9.48 (-1.2%)
Soybeans	+2.27 (+2.5%)	-0.11 (-4.3%)	-4.36 (-2%)
Canola	+0.11 (+0.4%)	-0.01 (-0.65%)	-0.14 (-0.3%)
Soymeal	n/a	n/a	-2.69 (-1.7%)
Soy oil	n/a	n/a	-0.67 (-1.8%)
Canola/rape meal	n/a	n/a	-0.03 (-0.1%)
Canola/rape oil	n/a	n/a	-0.04 (-0.2%)

Notes: n/a = not applicable. Baseline for these changes are 2007/08 values. These are marginally different to the model baseline values presented in Appendix 2.

The dynamic effect on subsequent plantings and the production base would result in a projected increase in the total area planted to these three crops of just under 3 million hectares, although this 'compensating' additional planting would not offset the yield reduction effects of no longer using biotech traits, resulting in a net fall in global production of the three crops of 14 million tonnes. In respect of the key oilseed derivatives of meal and oil, the reduction in the supply of the base seed (soybeans and rapeseed) would result in knock-on falls in global production of soymeal (1.7%), soy oil (1.8%), rapemeal (0.1%) and rape oil (0.2%). The total reduction in supply of these crops and key derivatives of meal and oil is projected to be 17.4 million tonnes.

The changes in the supply availability of these three crops and the resulting upward effect on prices are forecast to lead to falls in global trade of these crops/derivatives. The modelling suggests that world trade in these crops/derivatives would fall by about 6.6 million tonnes, of which the main changes would be decreased trade volumes of 3.2 million tonnes, 1.65 million tonnes and 1.24 million tonnes respectively for corn, soymeal and soybeans.

The model also predicts annual decreases in global consumption of these commodities and derivatives of 14.25 million tonnes. The main decreases in consumption would be for corn (8.07 million tonnes, a 0.98% decrease), soymeal (2.67 million tonnes: 1.7% decrease) and soy oil (0.64 million tonnes: a 1.7% decrease). Change in global consumption of canola/rapeseed derivatives would be marginal.

The analysis also identifies impacts on related grain and oilseed sectors. In addition to the impact on prices (see section 3.1.1), the production and consumption of grains such as wheat, barley and sorghum and oilseeds, notably sunflower, would be affected (Table 6). The global production of wheat is projected to fall by 0.1%, whilst the production of sorghum would increase by 0.5%. In relation to global consumption, this is projected to fall for wheat but increase for barley, sorghum, sunflower meal and oil.

Table 6: Potential global changes to other grains and oilseeds if biotech traits are no longer used

	Production (million tonnes)	**Consumption (million tonnes)**
Wheat	-0.61 (-0.1%)	0.09 (-0.01%)
Barley	Nil	+0.10 (+0.07%)
Sorghum	+0.32 (+0.5%)	+0.36 (+0.57%)
Sunflower meal	Nil	+0.02 (+0.2%)
Sunflower oil	Nil	+0.02 (+0.2%)

Taking both the impacts on the three directly affected sectors of corn, soy and canola and related grains and oilseeds, the net impacts of existing biotech traits (if no longer used in global agriculture) are an additional 2.64 million hectares of land being brought into grain and oilseed production. Despite this increase in total planted area, net production of these grains and oilseeds (excluding derivatives) would fall by 14.3 million tonnes. Inclusive of the main oilseed derivatives (including sunflower), net production is forecast to fall by 17.7 million tonnes. World trade in these commodities and derivatives would also fall (by 6.6 million tonnes) and global consumption of these grains and oilseed derivatives is forecast to fall by 15.4 million tonnes. Lastly, the model estimates that the cost of global consumption of these crops and derivatives would increase by $20 billion (3.6%) relative to the total cost of consumption of the (higher) biotech-inclusive level of world consumption. In unit terms the average cost of consumption would increase by about 4.6% from an average of $301/tonne to $315/tonne.

4.2 Country level

This section discusses the impact of biotech traits no longer being available at the global level on specific countries and regions of the world.

4.2.1 United States

If existing biotech traits were no longer available to farmers globally (including US farmers), the impact in the affected US cropping sectors would be significant (Table 7). The model analysis points to production of US corn and canola falling by 3% (10.8 million tonnes) and 5.7% (50,000 tonnes) respectively due mainly to reduced yields (loss of yield enhancing nature of the biotech traits). Soybean production, would, however potentially increase by 2.4 million tonnes due to increased plantings of soybeans (the yield losses to corn improving the relative competitive position of soybeans at the farm level).

Trade effects would be similar to the production impacts, with decreases in the volumes of exported corn and canola of about 10%. Soybean exports would, however, potentially increase significantly due to the additional production. The model also forecasts knock on effects in other sectors; plantings of wheat and sorghum would be expected to fall, resulting in decreased production of these crops (0.6% for wheat and 0.5% for sorghum). In contrast, plantings and production of barley are expected to increase by 1.1%. Lastly, domestic US consumption of corn, soybeans and canola is expected to fall by 2%, 0.5% and 2% respectively (caused by the higher prices: see section 4.1.1).

Table 7: Potential change to the US production base if biotech traits are no longer used (% change)

	Area)	Average yield	Production	Net trade (net exports)
Corn	-0.8%	-2.5%	-3%	-10%
Soybeans	+3.6%	0%	+3.4%	+14%
Canola	+0.2%	-5.9%	-5.7%	-10%

4.2.2 Argentina

The effect of no longer using biotech traits globally in the Argentine corn and soybean sectors is summarised in Table 8. Production of corn is forecast to fall by 3.1% (about 0.7million tonnes) due to reduced yields (loss of yield enhancing nature of the biotech traits). Output of soybeans is predicted to fall more significantly because of the negative effect on second crop soybeans, which accounted for 20% plus of the total Argentine soybean crop in 2006 (GM HT technology having contributed to shortening the production cycle for soybeans, allowing many farmers to plant a crop of soybeans after wheat in the same season). As such, no longer having access to this technology would potentially threaten plantings of second crop soy, resulting in a significant fall in total soy production (equal to almost 9 million tonnes).

The declines in production of soybeans and corn would have an important negative impact on the wider Argentine economy. Domestic consumption of both corn and soybeans is forecast to fall by about 1% and

7% respectively (due to reduced availability and higher prices). More importantly, the reduced levels of production would result in decreased volumes available for export, especially in the soybean and derivative sectors. Given that soybean exports have contributed, and continue to contribute, tax revenues to the Argentine Exchequer, this would result in important cuts in government tax revenues. Lastly, the modelling results suggest that production of other cereals, notably wheat and barley, would potentially increase by over 1% respectively due to increased plantings of these crops.

Table 8: Potential change to Argentine production base if biotech traits are no longer used (% change)

	Area	Average yield	Production	Net trade (net exports)
Corn	+1.6%	-4.6%	-3.1%	-3.9%
Soybeans	-18.5% (inclusive of loss of 2nd crop soy)	-0%	-18.8%	-81%
Soymeal	n/a	n/a	-7%	-7%
Soy oil	n/a	n/a	-7%	-8%

Note: n/a = not applicable. The model results presented in Appendix 2 differ from the changes presented in this table because the model inputs the loss of second crop soybeans as a yield decrease. The effects presented in this table therefore adjust the negative yield effect used in the modelling to an area change which is projected to be a 1.5% increase in first crop soybean plantings, relative to a 20% decrease in second crop soybeans.

4.2.3 Canada

The estimated impact of no longer making available the existing biotech traits in the global markets of corn, soybeans and canola on the relevant Canadian cropping sectors is summarised in Table 9. Production of corn and canola is forecast to fall by over 2% respectively (0.3 million tonnes for corn and 0.3 million tonnes of canola) due to reduced yields (loss of yield enhancing nature of the biotech traits). Soybean production would, however, likely increase (by over 2%) because of increased plantings (as in the US, the yield losses to corn improving the relative competitive position of soybeans at the farm level). The model predicts that domestic consumption and use of all three commodities and derivatives would fall by over 4% for both soybeans and canola and by about 1% for corn, due to higher prices (see section 4.1). Canada, a net importer of corn, increases its net imports because of the decline in production. Exports of soybeans would, however, potentially increase as decreased domestic consumption results in additional volumes becoming available for export. In contrast, exports of canola and derivatives would be expected to fall (exports being a major outlet for Canadian canola relative to domestic consumption, hence any additional supplies available for export from reduced domestic consumption being more than offset by the fall in production associated with the withdrawal of biotech traits). The changes in biotech crops also impact the other crop markets. With the increase in corn prices, wheat area in Canada declines,

as area shifts away from wheat to corn. This increases wheat prices and thus domestic use of wheat declines. Net exports of wheat in Canada increase since domestic use declines more than domestic supply, because of the relatively larger decline in stocks of wheat.

Table 9: Potential change to the Canadian production base if biotech traits are no longer used (% change)

	Area	Average yield	Production	Net trade (net exports)
Corn	+0.4%	-2.5%	-2.1%	+5.6%
Soybeans	+2.2%	0%	+2.2%	+8.8%
Canola	+0.2%	-3.1%	-2.9%	-1.5%
Soymeal	n/a	n/a	-1.8%	-3.3%
Soy oil	n/a	n/a	-1.8%	-3.3%
Canola/rape meal	n/a	n/a	-5.3%	-6.8%
Canola/rape oil	n/a	n/a	-5.3%	-6.8%
Wheat	-0.14%	0%	-0.14%	0.13%

Note: n/a = not applicable.

4.2.4 South Africa and the Philippines—corn sector

Both these countries currently use biotech IR technology in their corn sectors. Consequently, if this technology was no longer available to these and all farmers globally, there would be important negative impacts for those farmers who currently use the technology. At the national level in South Africa, average corn yields would be expected to fall by over 5%, resulting in a net 5.5% reduction in total corn production.[9] In the Philippines, where adoption of biotech IR corn traits is more recent and hence less widespread than in South Africa (5% of total crop compared to 63% of the total corn crop in South Africa), the national level impacts are an average decrease in corn yield of 1% and production falling by about 0.5%.[10]

The modelling results suggest that domestic consumption of corn is also expected to fall by over 1.5% in both countries (due to higher prices of corn). In terms of net trade, in the Philippines, imports would increase by about 0.1 million tonnes (50%), whilst in South Africa, exports (of corn) would fall by nearly 30% (about 0.45 million tonnes).

4.2.5 The European Union

There were two biotech traits in use commercially in EU-27 countries of relevance during the period 1998-2006: insect resistant corn in several member states and herbicide tolerant soybeans in Romania. The modelling analysis identifies negative impacts of no longer using these technologies (both in the EU

[9] Area planted is projected to fall by 0.5%
[10] Area planted is projected to increase by 0.7%

and globally).[11] Average EU 27 corn yields and production would be expected to fall marginally (by 0.2%),[12] whilst both consumption and net trade (imports) of corn would fall by 0.3% and 1.2% respectively (negative effect of higher world prices for corn). Average soybean yields across the EU would also be expected to fall by -3.2% and production would be lower by -1.3% due to the negative effect on yields and production of soybeans in the important EU soy producing country, Romania. This reduced supply of domestic soybeans is forecast to result in reductions in the EU production of soymeal and soy oil (by 1.1%). Usage of soymeal and soy oil is also forecast to fall, by 2.6% and 1.4% respectively (due to higher world prices).

5 Conclusions

This study quantified, through the use of agricultural commodity models, the impact of biotech traits on production, usage, trade and prices in the corn, soybean and canola sectors. The previous analysis (Brookes and Barfoot 2008) estimated that biotech crops, through the two main traits of insect resistance and herbicide tolerance, have added 53.3 million tonnes and 47.1 million tonnes respectively to global production of soybeans and corn in the period 1996-2006. The technology has also contributed an extra 3.2 million tonnes of canola.

The estimated impact of these additional volumes of production on markets and prices in the cereals and oilseeds sectors has been significant. Our modelling analysis of the potential impact of no longer using these traits in world agriculture shows that the world prices of these commodities, their key derivatives, and related cereal and oilseed crops would be significantly affected. World prices of corn, soybeans and canola would probably be 5.8%, 9.6% and 3.8% higher respectively than the baseline 2007 levels (when the technology was available for the analysis purposes). Prices of key derivatives of soybeans (meal and oil) would also be between 5% (oil) and 9% (meal) higher than the baseline levels, with rapeseed meal and oil prices being about 4% higher than baseline levels. World prices of related cereals and oilseeds would also be expected to rise by 3% to 4%.

The effect of no longer using the current biotech traits in the corn, soybeans and canola sectors would also impact both the supply and utilization of these crops, their derivatives and related markets for grain and oilseeds. Average global yields are estimated to fall by 1.5%, 4.3% and 0.65% respectively for corn,

[11] The removal of access to this technology has, in fact, occurred in relation to herbicide tolerant soybeans in Romania, which joined the EU in 2007 and hence had to adopt EU regulations relating to biotechnology. The planting of biotech herbicide tolerant soybeans is currently not permitted in the EU-27.

[12] Readers should note that biotech IR corn was planted on about 0.1 million hectares in the EU-27 in 2007, equal to 1.3% of total EU-27 corn planting.

soybeans and canola. Whilst there is likely to be some 'compensating' additional plantings (of just under 3 million hectares) of these three crops, this would not offset the yield reduction effects of no longer using biotech traits, resulting in a net fall in global production of the three crops of 14 million tonnes. The modelling also suggests that a fall in the supply availability of these three crops and the resulting upward effect on prices would lead to a projected decrease in global trade of these crops/derivatives (of 6.6 million tonnes), a 1.4% decrease in corn usage and a 1.7% decrease in usage of soymeal and soy oil (changes in global consumption of canola/rapeseed derivatives would be marginal).

The production and consumption of grains such as wheat, barley and sorghum and oilseeds, notably sunflower would also be affected (e.g., the global production and consumption of wheat would fall by 0.1% and 0.01% respectively).

Overall, the net impacts of existing biotech traits (if no longer used) in global agriculture are that an additional 2.64 million hectares of land would probably be brought into grain and oilseed production. Despite this, net production of grains and oilseeds (including derivatives) would potentially fall by 17.7 million tonnes[13] and global consumption would potentially fall by 15.4 million tonnes. The cost of consumption would also increase by $20 billion (3.6%) relative to the total cost of consumption of the (higher) biotech-inclusive level of world consumption. In unit terms, the net cost of consumption would increase by about 4.6%.

The impacts identified in this analysis are probably conservative, reflecting the limitations of the methodology used to estimate the productivity enhancing effects of biotech traits so far used in global agriculture. In particular, the limited research conducted to date into the impact of the cost-reducing effect of biotechnology (notably in herbicide tolerant soybeans) on prices suggests that the price effects identified in this paper represent only part of the total price impact of the technology. Subsequent research might usefully extend this analysis to incorporate consideration of the cost-reducing effect of the technology, especially HT technology, and to examination of the cotton sector.

[13] Sum of tables 5 and 6.

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Appendix 1: Agricultural modelling system – methodological details

A.1 General Description of the Modelling System

This study uses part of a broad modelling system of world agricultural economy comprised of US and international multi-market, partial-equilibrium models. The models are econometric and simulation models covering all major temperate crops, sugar, ethanol and bio-diesel, dairy, and livestock and meat products for all major producing and consuming countries and calibrated on most recently available data. A Rest-of-the-World aggregate is included to close the models. Table A1 presents a detailed list of commodity and country coverage. Extensive market linkages exist in these models, reflecting derived demand for feed in livestock and dairy sectors, competition for land in production, and consumer substitution possibilities for close substitutes such as vegetable oils and meat types.

Table A1. Model Inputs and Output

Commodities	**Major Countries/Regions**	**Exogenous Inputs**	**Historical Data (Inputs)**	**Output by commodity and country**
Grains Corn Wheat Sorghum Barley **Oilseeds** Soybeans Rapeseed Sunflower **Sugar** **Biofuels** Ethanol Biodiesel	**North America** United States, Canada, Mexico **South America** Brazil, Argentina, Colombia, etc. **Asia** China, Japan, India, Indonesia, Malaysia, etc. **Africa** South Africa, Egypt, etc. **European Union** **Oceania** Australia, **Middle East** Iran, Saudi Arabia, etc. **Rest of the World**	Population GDP GDP deflator Exchange rate Population Policy variables	Production Consumption Exports Imports Ending stocks Domestic prices World prices	World prices Domestic prices Production Consumption Net trade Stocks Area harvested Yield

The models capture the biological, technical, and economic relationships among key variables within a particular commodity and across commodities. They are based on historical data analysis, current academic research, and a reliance on accepted economic, agronomic, and biological relationships in agricultural production and markets. There is a link between the US and international models, which is made through prices and net trade equations. The models are used to establish commodity projections for

a baseline and for policy analysis, and are used extensively for the market outlook and policy analysis. This set of agricultural models have been used in a number of studies including Elobeid et al. (2007), Fabiosa et al. (2007), Fabiosa et al. (2005), and Tokgoz et al. (2008).

In general, for each commodity sector, the economic relationship that supply equals demand is maintained by determining a market-clearing price for the commodity. In countries where domestic prices are not solved endogenously, these prices are modelled as a function of the world price using a price transmission equation. Since econometric models for each sector can be linked, changes in one commodity sector will impact other sectors. A detailed description of the models is available at http://www.fapri.iastate.edu/models/. Figure A1 provides a diagram of the overall modelling system. For this particular study, the U.S. Crops, International Grains, International Oilseed, International Sugar and International Bio-fuels models were used.

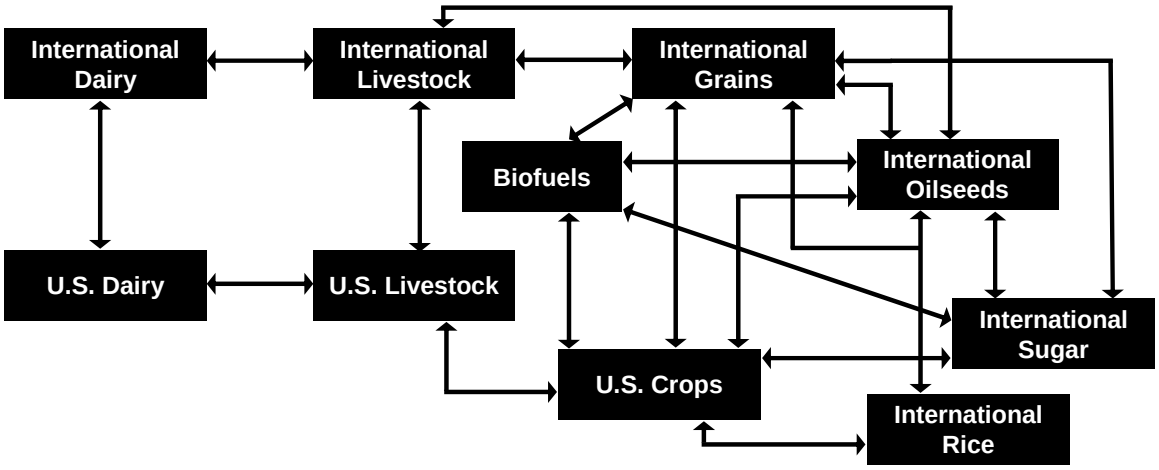

Figure A1: Model Interactions: Trade, Prices and Physical Flows

More specifically in terms of the structure of the models, the following identity is satisfied for each country/region and the world:

Beginning Stock + Production + Imports = Ending Stock + Consumption + Exports (A1)

Production is divided into yield and area equations, while consumption is divided into feed and non-feed demand. The models include behavioural equations for area harvested, yield, crop production on the supply side, and per capita consumption and ending stocks on the demand side. Equilibrium prices, quantities, and net trade are determined by equating excess supply and excess demand across countries and regions. To satisfy the identity in equation (A1), two different methods are used. In most of the countries, domestic price is modelled as a function of the world price with a price transmission equation,

and the identity is satisfied with one of the variables set as the residual. In other cases, prices are solved to satisfy the identity.

Agricultural and trade policies in each country are included in the models to the extent that they affect the supply and demand decisions of the economic agents. Examples of these include taxes on exports and imports, tariffs, tariff rate quotas, export subsidies, intervention prices, and set-aside rates. The models assume that the existing agricultural and trade policy variables will remain unchanged in the outlook period. Macroeconomic variables, such as GDP, population, and exchange rates, are exogenous variables that drive the projections of the model. The models also include an adjustment for marketing-year differences by including a residual that is equal to world exports minus world imports, which ensures that world demand equals world supply.

All models are calibrated on 2007/08 marketing year data for crops and 2007 calendar year data for livestock and biofuels, and ten-year projections for supply and utilization of commodities and prices are generated for the period between 2008 and 2017. The models also adjust for marketing-year differences by including a residual that is equal to world exports minus world imports, which ensures that world demand equals world supply. Elasticity values for supply and demand responses are based on econometric analysis and on consensus estimates. Elasticity parameters estimates and policy variables are available at http://www.fapri.iastate.edu/tools/.

Data for commodity supply and utilization are obtained from the F.O. Lichts online database, the Food and Agriculture Organization (FAO) of the United Nations (FAOSTAT Online, 2006), the Production, Supply and Distribution View (PS&D) of the US Department of Agriculture (USDA), and the European Commission Directorate General for Energy and Transport, the ANFAVEA (2005) and UNICA (2006). Supply and utilization data include production, consumption, net trade and stocks. The macroeconomic data are gathered from the International Monetary Fund and Global Insight.

Appendix 2: Scenario Results

Wheat Prices

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
U.S. FOB Gulf				(U.S. Dollars per Metric Ton)						
Baseline	251.95	252.04	258.65	257.80	261.80	264.06	266.98	270.41	272.93	273.75
Scenario 1	255.89	260.37	267.10	264.47	268.57	271.17	273.74	276.99	279.76	280.78
Percent Change	1.56%	3.31%	3.27%	2.58%	2.59%	2.69%	2.53%	2.43%	2.50%	2.57%
Canadian Wheat Board										
Baseline	262.60	262.06	267.48	266.15	269.33	270.37	271.87	274.00	275.66	276.48
Scenario 1	265.99	269.20	274.65	271.77	275.07	276.40	277.61	279.59	281.47	282.47
Percent Change	1.29%	2.73%	2.68%	2.11%	2.13%	2.23%	2.11%	2.04%	2.11%	2.16%
AWB Limited Export Quote										
Baseline	252.70	251.43	257.05	256.47	259.85	261.86	264.39	267.37	269.58	270.34
Scenario 1	256.04	258.60	264.41	262.32	265.75	268.04	270.28	273.11	275.53	276.45
Percent Change	1.32%	2.85%	2.86%	2.28%	2.27%	2.36%	2.23%	2.15%	2.21%	2.26%
European Union Market										
Baseline	270.66	252.49	241.79	237.26	231.78	230.18	231.70	233.38	235.10	236.16
Scenario 1	274.11	255.21	244.21	239.81	234.39	232.74	234.34	236.12	237.94	239.14
Percent Change	1.27%	1.08%	1.00%	1.08%	1.13%	1.11%	1.14%	1.17%	1.21%	1.26%

World Wheat Supply and Utilization

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Area Harvested					(Thousand Hectares)					
Baseline	222,149	221,970	219,530	220,580	220,862	220,987	221,245	221,363	221,426	221,668
Scenario 1	222,096	221,555	219,352	220,685	220,838	220,943	221,229	221,338	221,386	221,626
Percent Change	-0.02%	-0.19%	-0.08%	0.05%	-0.01%	-0.02%	-0.01%	-0.01%	-0.02%	-0.02%
Yield					(Metric Tons per Hectare)					
Baseline	2.92	2.93	2.96	2.98	3.00	3.03	3.05	3.07	3.10	3.12
Scenario 1	2.92	2.93	2.96	2.98	3.00	3.03	3.05	3.07	3.10	3.12
Percent Change	-0.02%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Production					(Thousand Metric Tons)					
Baseline	648,567	650,692	649,049	657,034	662,973	668,541	674,503	680,056	685,459	691,360
Scenario 1	648,294	649,468	648,582	657,345	662,873	668,398	674,438	679,951	685,304	691,199
Percent Change	-0.04%	-0.19%	-0.07%	0.05%	-0.02%	-0.02%	-0.01%	-0.02%	-0.02%	-0.02%
Beginning Stocks										
Baseline	111,043	128,080	133,956	134,678	136,261	137,314	138,218	138,988	139,655	140,416
Scenario 1	111,043	127,138	131,963	132,452	134,419	135,564	136,444	137,304	138,047	138,804
Percent Change	0.00%	-0.74%	-1.49%	-1.65%	-1.35%	-1.27%	-1.28%	-1.21%	-1.15%	-1.15%
Domestic Supply										
Baseline	759,610	778,772	783,005	791,712	799,235	805,854	812,720	819,044	825,114	831,777
Scenario 1	759,337	776,605	780,545	789,797	797,292	803,962	810,882	817,254	823,350	830,003
Percent Change	-0.04%	-0.28%	-0.31%	-0.24%	-0.24%	-0.23%	-0.23%	-0.22%	-0.21%	-0.21%
Feed Use										
Baseline	106,204	110,104	110,389	111,272	112,283	112,932	113,533	114,211	114,658	115,137
Scenario 1	106,652	110,543	110,836	111,712	112,657	113,336	113,921	114,568	115,024	115,514
Percent Change	0.42%	0.40%	0.41%	0.40%	0.33%	0.36%	0.34%	0.31%	0.32%	0.33%
Food and Other										
Baseline	525,325	534,712	537,938	544,178	549,639	554,705	560,199	565,178	570,040	575,047
Scenario 1	525,547	534,099	537,258	543,666	549,071	554,181	559,657	564,640	569,522	574,524
Percent Change	0.04%	-0.11%	-0.13%	-0.09%	-0.10%	-0.09%	-0.10%	-0.10%	-0.09%	-0.09%
Ending Stocks										
Baseline	128,080	133,956	134,678	136,261	137,314	138,218	138,988	139,655	140,416	141,593
Scenario 1	127,138	131,963	132,452	134,419	135,564	136,444	137,304	138,047	138,804	139,965
Percent Change	-0.74%	-1.49%	-1.65%	-1.35%	-1.27%	-1.28%	-1.21%	-1.15%	-1.15%	-1.15%
Domestic Use										
Baseline	759,610	778,772	783,005	791,712	799,235	805,854	812,720	819,044	825,114	831,777
Scenario 1	759,337	776,605	780,545	789,797	797,292	803,962	810,882	817,254	823,350	830,003
Percent Change	-0.04%	-0.28%	-0.31%	-0.24%	-0.24%	-0.23%	-0.23%	-0.22%	-0.21%	-0.21%
Trade *										
Baseline	89,343	94,120	94,202	95,988	98,715	100,937	103,167	105,148	106,888	108,747
Scenario 1	89,429	94,198	94,095	95,910	98,588	100,845	103,045	105,056	106,839	108,694
Percent Change	0.10%	0.08%	-0.11%	-0.08%	-0.13%	-0.09%	-0.12%	-0.09%	-0.05%	-0.05%
Stocks-to-Use Ratio					(Percent)					
Baseline	20.28	20.77	20.77	20.79	20.74	20.70	20.63	20.56	20.51	20.52
Scenario 1	20.11	20.47	20.44	20.51	20.49	20.44	20.38	20.32	20.28	20.28
Percent Change	-0.84%	-1.46%	-1.62%	-1.34%	-1.25%	-1.27%	-1.19%	-1.13%	-1.13%	-1.13%

* Excludes intraregional trade.

Coarse Grain Prices

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Corn (FOB Gulf)				(U.S. Dollars per Metric Ton)						
Baseline	196	216	209	209	215	215	217	221	221	220
Scenario 1	206	229	222	219	226	226	227	231	231	231
Percent Change	4.97%	6.32%	6.08%	4.89%	4.80%	5.17%	4.73%	4.51%	4.78%	4.94%
Sorghum (FOB Gulf)										
Baseline	175	191	183	184	189	188	191	194	195	195
Scenario 1	181	199	192	191	196	195	197	201	202	202
Percent Change	3.64%	4.60%	4.49%	3.50%	3.56%	3.87%	3.47%	3.36%	3.61%	3.71%
Barley (Canada Feed)										
Baseline	146	153	153	154	158	161	164	169	172	175
Scenario 1	149	159	159	159	162	166	169	173	177	180
Percent Change	2.15%	3.87%	3.89%	3.21%	2.96%	3.14%	2.95%	2.71%	2.78%	2.85%
Corn (EU)										
Baseline	259	234	225	221	217	215	216	217	218	217
Scenario 1	264	239	229	225	221	219	220	221	222	222
Percent Change	1.94%	1.93%	1.85%	1.79%	1.83%	1.89%	1.87%	1.88%	1.97%	2.06%
Barley (EU)										
Baseline	245	226	217	214	209	208	209	211	212	213
Scenario 1	248	228	219	216	211	210	211	213	214	215
Percent Change	1.17%	1.03%	0.92%	0.99%	1.03%	1.03%	1.05%	1.07%	1.11%	1.16%

World Corn Supply and Utilization

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Area Harvested					(Thousand Hectares)					
Baseline	160,424	161,061	166,781	168,047	167,954	170,035	170,820	171,280	172,286	172,931
Scenario 1	160,599	161,436	167,628	169,176	168,638	170,345	171,256	171,616	172,407	173,089
Percent Change	0.11%	0.23%	0.51%	0.67%	0.41%	0.18%	0.26%	0.20%	0.07%	0.09%
Yield					(Metric Tons per Hectare)					
Baseline	4.96	5.03	5.14	5.25	5.31	5.39	5.47	5.53	5.60	5.67
Scenario 1	4.90	4.95	5.05	5.17	5.22	5.29	5.37	5.43	5.50	5.56
Percent Change	-1.18%	-1.60%	-1.72%	-1.61%	-1.60%	-1.76%	-1.78%	-1.75%	-1.82%	-1.84%
Production					(Thousand Metric Tons)					
Baseline	795,217	810,266	856,591	882,789	891,255	915,958	934,479	947,376	964,302	980,380
Scenario 1	786,714	799,131	846,138	874,440	880,580	901,471	920,223	932,587	947,439	963,237
Percent Change	-1.07%	-1.37%	-1.22%	-0.95%	-1.20%	-1.58%	-1.53%	-1.56%	-1.75%	-1.75%
Beginning Stocks										
Baseline	102,533	103,581	97,074	101,584	106,107	103,897	105,121	106,391	105,725	106,354
Scenario 1	102,533	100,234	91,708	95,717	101,391	99,763	100,321	101,790	101,531	101,839
Percent Change	0.00%	-3.23%	-5.53%	-5.78%	-4.44%	-3.98%	-4.57%	-4.33%	-3.97%	-4.24%
Domestic Supply										
Baseline	897,750	913,848	953,665	984,374	997,362	1,019,854	1,039,600	1,053,768	1,070,027	1,086,734
Scenario 1	889,248	899,365	937,846	970,158	981,971	1,001,234	1,020,544	1,034,377	1,048,969	1,065,076
Percent Change	-0.95%	-1.58%	-1.66%	-1.44%	-1.54%	-1.83%	-1.83%	-1.84%	-1.97%	-1.99%
Feed Use										
Baseline	490,514	486,098	497,113	506,626	509,382	517,178	523,330	527,204	532,514	538,892
Scenario 1	487,048	480,003	490,879	501,903	504,689	511,585	518,109	522,215	527,057	533,278
Percent Change	-0.71%	-1.25%	-1.25%	-0.93%	-0.92%	-1.08%	-1.00%	-0.95%	-1.02%	-1.04%
Food and Other										
Baseline	303,655	330,676	354,968	371,640	384,084	397,555	409,878	420,839	431,159	439,609
Scenario 1	301,966	327,653	351,250	366,864	377,519	389,329	400,645	410,631	420,073	428,408
Percent Change	-0.56%	-0.91%	-1.05%	-1.29%	-1.71%	-2.07%	-2.25%	-2.43%	-2.57%	-2.55%
Ending Stocks										
Baseline	103,581	97,074	101,584	106,107	103,897	105,121	106,391	105,725	106,354	108,233
Scenario 1	100,234	91,708	95,717	101,391	99,763	100,321	101,790	101,531	101,839	103,390
Percent Change	-3.23%	-5.53%	-5.78%	-4.44%	-3.98%	-4.57%	-4.33%	-3.97%	-4.24%	-4.47%
Domestic Use										
Baseline	897,750	913,848	953,665	984,374	997,362	1,019,854	1,039,600	1,053,768	1,070,027	1,086,734
Scenario 1	889,248	899,365	937,846	970,158	981,971	1,001,234	1,020,544	1,034,377	1,048,969	1,065,076
Percent Change	-0.95%	-1.58%	-1.66%	-1.44%	-1.54%	-1.83%	-1.83%	-1.84%	-1.97%	-1.99%
Trade *										
Baseline	85,330	82,314	83,886	86,491	87,216	89,114	91,056	92,342	94,072	96,335
Scenario 1	83,408	79,105	80,681	83,874	84,859	86,613	88,685	90,151	91,852	94,045
Percent Change	-2.25%	-3.90%	-3.82%	-3.03%	-2.70%	-2.81%	-2.60%	-2.37%	-2.36%	-2.38%
Stocks-to-Use Ratio					(Percent)					
Baseline	13.04	11.89	11.92	12.08	11.63	11.49	11.40	11.15	11.04	11.06
Scenario 1	12.70	11.35	11.37	11.67	11.31	11.14	11.08	10.88	10.75	10.75
Percent Change	-2.60%	-4.46%	-4.66%	-3.40%	-2.75%	-3.10%	-2.82%	-2.40%	-2.57%	-2.80%

* Excludes intraregional trade.

World Barley Supply and Utilization

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Area Harvested					(Thousand Hectares)					
Baseline	56,910	56,795	57,012	57,019	57,048	57,086	57,213	57,237	57,304	57,387
Scenario 1	56,895	56,761	57,024	57,044	57,071	57,093	57,225	57,255	57,316	57,397
Percent Change	-0.03%	-0.06%	0.02%	0.04%	0.04%	0.01%	0.02%	0.03%	0.02%	0.02%
Yield					(Metric Tons per Hectare)					
Baseline	2.53	2.55	2.56	2.57	2.59	2.60	2.62	2.63	2.64	2.65
Scenario 1	2.53	2.55	2.56	2.57	2.59	2.60	2.62	2.63	2.64	2.65
Percent Change	-0.03%	0.05%	0.05%	0.04%	0.02%	0.03%	0.03%	0.02%	0.02%	0.02%
Production					(Thousand Metric Tons)					
Baseline	144,105	144,573	145,914	146,705	147,629	148,556	149,633	150,443	151,326	152,241
Scenario 1	144,027	144,556	146,021	146,822	147,725	148,619	149,706	150,527	151,393	152,306
Percent Change	-0.05%	-0.01%	0.07%	0.08%	0.07%	0.04%	0.05%	0.06%	0.04%	0.04%
Beginning Stocks										
Baseline	15,413	18,066	18,557	19,015	19,259	19,355	19,455	19,562	19,605	19,710
Scenario 1	15,413	17,876	18,260	18,718	19,005	19,115	19,201	19,319	19,377	19,475
Percent Change	0.00%	-1.05%	-1.60%	-1.56%	-1.32%	-1.24%	-1.30%	-1.24%	-1.17%	-1.19%
Domestic Supply										
Baseline	159,518	162,639	164,471	165,720	166,888	167,912	169,088	170,005	170,931	171,951
Scenario 1	159,440	162,432	164,281	165,540	166,730	167,733	168,907	169,847	170,769	171,781
Percent Change	-0.05%	-0.13%	-0.12%	-0.11%	-0.09%	-0.11%	-0.11%	-0.09%	-0.09%	-0.10%
Feed Use										
Baseline	97,028	98,901	99,685	100,262	100,904	101,440	102,101	102,621	103,072	103,537
Scenario 1	97,166	99,042	99,843	100,390	101,033	101,564	102,213	102,738	103,191	103,655
Percent Change	0.14%	0.14%	0.16%	0.13%	0.13%	0.12%	0.11%	0.11%	0.12%	0.11%
Food and Other										
Baseline	44,424	45,181	45,772	46,198	46,629	47,017	47,425	47,778	48,149	48,524
Scenario 1	44,397	45,130	45,720	46,145	46,583	46,968	47,375	47,732	48,103	48,477
Percent Change	-0.06%	-0.11%	-0.11%	-0.11%	-0.10%	-0.10%	-0.11%	-0.10%	-0.10%	-0.10%
Ending Stocks										
Baseline	18,066	18,557	19,015	19,259	19,355	19,455	19,562	19,605	19,710	19,890
Scenario 1	17,876	18,260	18,718	19,005	19,115	19,201	19,319	19,377	19,475	19,650
Percent Change	-1.05%	-1.60%	-1.56%	-1.32%	-1.24%	-1.30%	-1.24%	-1.17%	-1.19%	-1.21%
Domestic Use										
Baseline	159,518	162,639	164,471	165,720	166,888	167,912	169,088	170,005	170,931	171,951
Scenario 1	159,440	162,432	164,281	165,540	166,730	167,733	168,907	169,847	170,769	171,781
Percent Change	-0.05%	-0.13%	-0.12%	-0.11%	-0.09%	-0.11%	-0.11%	-0.09%	-0.09%	-0.10%
Trade *										
Baseline	15,871	16,721	17,067	17,246	17,430	17,539	17,648	17,729	17,783	17,829
Scenario 1	15,918	16,786	17,110	17,270	17,454	17,565	17,669	17,749	17,804	17,850
Percent Change	0.30%	0.39%	0.25%	0.14%	0.14%	0.15%	0.12%	0.11%	0.12%	0.11%
Stocks-to-Use Ratio					(Percent)					
Baseline	12.77	12.88	13.07	13.15	13.12	13.10	13.08	13.04	13.03	13.08
Scenario 1	12.63	12.67	12.86	12.97	12.95	12.93	12.92	12.88	12.87	12.92
Percent Change	-1.13%	-1.66%	-1.63%	-1.37%	-1.30%	-1.35%	-1.28%	-1.21%	-1.24%	-1.25%

* Excludes intraregional trade.

World Sorghum Supply and Utilization

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Area Harvested					(Thousand Hectares)					
Baseline	41,252	40,889	41,670	41,378	41,134	41,487	41,507	41,724	41,976	42,008
Scenario 1	41,265	41,116	41,983	41,694	41,366	41,732	41,796	41,984	42,233	42,296
Percent Change	0.03%	0.56%	0.75%	0.76%	0.56%	0.59%	0.70%	0.62%	0.61%	0.69%
Yield					(Metric Tons per Hectare)					
Baseline	1.54	1.53	1.54	1.56	1.57	1.59	1.60	1.61	1.62	1.64
Scenario 1	1.54	1.53	1.54	1.56	1.57	1.59	1.60	1.61	1.63	1.64
Percent Change	0.05%	0.03%	0.01%	0.04%	0.06%	0.04%	0.05%	0.05%	0.04%	0.05%
Production					(Thousand Metric Tons)					
Baseline	63,439	62,547	64,362	64,602	64,739	65,874	66,423	67,263	68,200	68,820
Scenario 1	63,494	62,915	64,850	65,122	65,143	66,286	66,917	67,718	68,648	69,325
Percent Change	0.09%	0.59%	0.76%	0.81%	0.62%	0.63%	0.74%	0.68%	0.66%	0.73%
Beginning Stocks										
Baseline	3,972	4,372	4,013	4,174	4,257	4,229	4,308	4,320	4,304	4,334
Scenario 1	3,972	4,273	3,853	3,998	4,110	4,085	4,151	4,176	4,166	4,187
Percent Change	0.00%	-2.26%	-3.99%	-4.22%	-3.46%	-3.41%	-3.64%	-3.34%	-3.21%	-3.38%
Domestic Supply										
Baseline	67,411	66,919	68,376	68,776	68,997	70,103	70,731	71,583	72,505	73,154
Scenario 1	67,466	67,189	68,703	69,120	69,253	70,371	71,068	71,894	72,814	73,513
Percent Change	0.08%	0.40%	0.48%	0.50%	0.37%	0.38%	0.48%	0.43%	0.43%	0.49%
Feed Use										
Baseline	26,931	26,123	26,534	26,529	26,630	26,808	26,791	26,846	26,937	26,999
Scenario 1	27,069	26,288	26,686	26,691	26,759	26,933	26,929	26,966	27,049	27,117
Percent Change	0.51%	0.63%	0.57%	0.61%	0.48%	0.47%	0.51%	0.45%	0.42%	0.44%
Food and Other										
Baseline	36,108	36,783	37,668	37,989	38,138	38,987	39,620	40,432	41,234	41,774
Scenario 1	36,123	37,048	38,020	38,319	38,409	39,287	39,963	40,761	41,578	42,165
Percent Change	0.04%	0.72%	0.94%	0.87%	0.71%	0.77%	0.87%	0.81%	0.83%	0.94%
Ending Stocks										
Baseline	4,372	4,013	4,174	4,257	4,229	4,308	4,320	4,304	4,334	4,381
Scenario 1	4,273	3,853	3,998	4,110	4,085	4,151	4,176	4,166	4,187	4,231
Percent Change	-2.26%	-3.99%	-4.22%	-3.46%	-3.41%	-3.64%	-3.34%	-3.21%	-3.38%	-3.43%
Domestic Use										
Baseline	67,411	66,919	68,376	68,776	68,997	70,103	70,731	71,583	72,505	73,154
Scenario 1	67,466	67,189	68,703	69,120	69,253	70,371	71,068	71,894	72,814	73,513
Percent Change	0.08%	0.40%	0.48%	0.50%	0.37%	0.38%	0.48%	0.43%	0.43%	0.49%
Trade *										
Baseline	6,109	5,621	5,557	5,761	5,823	5,935	6,100	6,192	6,277	6,409
Scenario 1	6,094	5,600	5,441	5,721	5,817	5,918	6,075	6,178	6,255	6,371
Percent Change	-0.24%	-0.38%	-2.10%	-0.70%	-0.10%	-0.29%	-0.40%	-0.23%	-0.35%	-0.59%
Stocks-to-Use Ratio					(Percent)					
Baseline	6.94	6.38	6.50	6.60	6.53	6.55	6.50	6.40	6.36	6.37
Scenario 1	6.76	6.08	6.18	6.32	6.27	6.27	6.24	6.15	6.10	6.11
Percent Change	-2.50%	-4.64%	-4.96%	-4.19%	-4.00%	-4.26%	-4.03%	-3.85%	-4.03%	-4.14%

* Excludes intraregional trade.

Soybean and Product Prices

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Soybean Prices										
Illinois Processor				(U.S. Dollars per Metric Ton)						
Baseline	398	378	386	399	388	395	405	406	409	412
Scenario 1	442	419	415	432	422	426	437	439	441	445
Percent Change	11.18%	10.81%	7.37%	8.21%	8.81%	7.85%	7.83%	8.15%	7.94%	8.03%
CIF Rotterdam										
Baseline	511	486	496	511	497	505	517	518	521	523
Scenario 1	567	537	531	552	540	544	557	559	561	565
Percent Change	10.94%	10.58%	7.22%	8.04%	8.63%	7.69%	7.67%	7.98%	7.78%	7.86%
Soybean Meal Prices										
FOB Decatur 48%				(U.S. Dollars per Metric Ton)						
Baseline	307	290	282	284	283	285	289	288	285	281
Scenario 1	337	317	303	307	308	309	314	314	311	308
Percent Change	9.82%	9.39%	7.57%	8.20%	8.65%	8.37%	8.52%	8.88%	9.05%	9.47%
CIF Rotterdam										
Baseline	402	381	370	373	372	374	380	378	374	369
Scenario 1	441	416	397	403	404	405	411	411	407	403
Percent Change	9.61%	9.19%	7.42%	8.03%	8.47%	8.20%	8.35%	8.69%	8.86%	9.27%
Soybean Oil Prices										
FOB Decatur				(U.S. Dollars per Metric Ton)						
Baseline	1,034	1,029	1,075	1,102	1,055	1,070	1,094	1,111	1,140	1,171
Scenario 1	1,084	1,092	1,125	1,164	1,125	1,139	1,168	1,190	1,221	1,254
Percent Change	4.83%	6.13%	4.62%	5.60%	6.61%	6.45%	6.78%	7.16%	7.11%	7.11%
FOB Rotterdam										
Baseline	1,255	1,249	1,304	1,336	1,280	1,298	1,326	1,346	1,381	1,418
Scenario 1	1,314	1,324	1,363	1,409	1,363	1,380	1,414	1,441	1,477	1,516
Percent Change	4.73%	6.01%	4.53%	5.49%	6.47%	6.31%	6.64%	7.01%	6.96%	6.97%

Rapeseed and Product Prices

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Rapeseed Prices										
Cash Vancouver				(U.S. Dollars per Metric Ton)						
Baseline	411	411	414	396	393	396	397	398	402	405
Scenario 1	426	427	428	413	410	413	415	417	422	426
Percent Change	3.58%	3.88%	3.58%	4.10%	4.32%	4.32%	4.58%	4.79%	4.89%	5.06%
CIF Hamburg										
Baseline	529	529	532	510	505	509	510	512	518	521
Scenario 1	549	550	552	531	527	531	534	537	543	548
Percent Change	3.66%	3.96%	3.65%	4.19%	4.41%	4.41%	4.68%	4.89%	4.99%	5.17%
Rapeseed Meal Price										
FOB Hamburg				(U.S. Dollars per Metric Ton)						
Baseline	303	301	295	294	301	305	308	309	308	304
Scenario 1	316	314	305	304	311	315	318	319	318	315
Percent Change	4.32%	4.10%	3.57%	3.49%	3.34%	3.29%	3.28%	3.28%	3.37%	3.56%
Rapeseed Oil Price										
FOB Hamburg				(U.S. Dollars per Metric Ton)						
Baseline	1,310	1,344	1,385	1,347	1,338	1,362	1,385	1,413	1,456	1,502
Scenario 1	1,345	1,384	1,423	1,391	1,385	1,409	1,436	1,467	1,512	1,560
Percent Change	2.65%	2.98%	2.78%	3.22%	3.50%	3.48%	3.65%	3.81%	3.81%	3.83%

Sunflower Seed and Product Prices

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Sunflower Seed Price										
CIF Lower Rhine				(U.S. Dollars per Metric Ton)						
Baseline	601	588	596	587	577	578	580	579	579	578
Scenario 1	617	610	614	606	596	596	599	598	598	598
Percent Change	2.59%	3.73%	3.05%	3.13%	3.30%	3.16%	3.24%	3.32%	3.31%	3.40%
Sunflower Meal Price										
CIF Rotterdam				(U.S. Dollars per Metric Ton)						
Baseline	276	270	265	264	268	272	275	274	271	266
Scenario 1	285	280	274	272	276	280	282	282	279	275
Percent Change	3.49%	3.76%	3.20%	3.04%	3.00%	2.93%	2.88%	2.89%	2.97%	3.13%
Sunflower Oil Price										
FOB NW Europe				(U.S. Dollars per Metric Ton)						
Baseline	1,432	1,424	1,463	1,471	1,467	1,490	1,517	1,545	1,577	1,609
Scenario 1	1,451	1,453	1,487	1,497	1,495	1,517	1,546	1,575	1,607	1,639
Percent Change	1.35%	2.00%	1.63%	1.78%	1.92%	1.83%	1.88%	1.93%	1.90%	1.89%

World Soybean Sector Supply and Utilization

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Soybeans										
Area Harvested				(Thousand Hectares)						
Baseline	96,946	99,931	100,256	100,770	102,729	103,231	103,792	105,049	105,939	106,803
Scenario 1	97,822	102,806	103,924	103,881	105,798	106,571	107,050	108,264	109,268	110,143
Percent Change	0.90%	2.88%	3.66%	3.09%	2.99%	3.24%	3.14%	3.06%	3.14%	3.13%
Production				(Thousand Metric Tons)						
Baseline	242,217	252,279	255,277	258,491	266,315	270,217	274,164	280,326	285,531	290,682
Scenario 1	233,417	248,311	253,470	255,008	262,557	267,188	270,815	276,729	282,179	287,262
Percent Change	-3.63%	-1.57%	-0.71%	-1.35%	-1.41%	-1.12%	-1.22%	-1.28%	-1.17%	-1.18%
Beginning Stocks										
Baseline	47,227	48,060	49,742	50,129	49,637	50,547	50,748	50,506	50,755	50,910
Scenario 1	47,227	45,053	46,583	47,617	46,967	47,645	47,971	47,716	47,850	48,013
Percent Change	0.00%	-6.26%	-6.35%	-5.01%	-5.38%	-5.74%	-5.47%	-5.52%	-5.72%	-5.69%
Domestic Supply										
Baseline	289,444	300,339	305,019	308,621	315,952	320,764	324,913	330,832	336,286	341,591
Scenario 1	280,643	293,364	300,052	302,625	309,524	314,833	318,785	324,445	330,029	335,275
Percent Change	-3.04%	-2.32%	-1.63%	-1.94%	-2.03%	-1.85%	-1.89%	-1.93%	-1.86%	-1.85%
Crush										
Baseline	209,533	218,369	222,558	226,309	232,128	236,595	240,822	246,127	251,150	256,042
Scenario 1	204,327	214,881	220,184	223,155	228,795	233,559	237,612	242,789	247,905	252,748
Percent Change	-2.48%	-1.60%	-1.07%	-1.39%	-1.44%	-1.28%	-1.33%	-1.36%	-1.29%	-1.29%
Food Use										
Baseline	14,504	14,829	14,949	15,131	15,384	15,462	15,497	15,624	15,715	15,887
Scenario 1	14,182	14,484	14,723	14,900	15,112	15,218	15,257	15,366	15,468	15,637
Percent Change	-2.22%	-2.33%	-1.51%	-1.53%	-1.77%	-1.58%	-1.55%	-1.65%	-1.58%	-1.57%
Other Use										
Baseline	16,473	16,963	16,948	17,107	17,457	17,524	17,653	17,891	18,075	18,283
Scenario 1	16,224	16,981	17,093	17,167	17,537	17,651	17,765	18,004	18,208	18,409
Percent Change	-1.51%	0.10%	0.85%	0.35%	0.45%	0.73%	0.64%	0.63%	0.74%	0.69%
Residual										
Baseline	436	436	436	436	436	436	436	436	436	436
Scenario 1	436	436	436	436	436	436	436	436	436	436
Percent Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ending Stocks										
Baseline	48,060	49,742	50,129	49,637	50,547	50,748	50,506	50,755	50,910	50,943
Scenario 1	45,053	46,583	47,617	46,967	47,645	47,971	47,716	47,850	48,013	48,045
Percent Change	-6.26%	-6.35%	-5.01%	-5.38%	-5.74%	-5.47%	-5.52%	-5.72%	-5.69%	-5.69%
Domestic Use										
Baseline	289,006	300,339	305,020	308,621	315,952	320,765	324,913	330,832	336,286	341,592
Scenario 1	280,222	293,364	300,053	302,625	309,525	314,834	318,786	324,446	330,030	335,276
Percent Change	-3.04%	-2.32%	-1.63%	-1.94%	-2.03%	-1.85%	-1.89%	-1.93%	-1.86%	-1.85%
Trade *										
Baseline	70,094	72,279	73,476	75,117	77,980	79,962	81,824	84,209	86,428	88,696
Scenario 1	68,359	71,000	73,071	74,718	77,695	80,052	82,051	84,462	86,814	89,144
Percent Change	-2.48%	-1.77%	-0.55%	-0.53%	-0.36%	0.11%	0.28%	0.30%	0.45%	0.51%

World Soybean Sector Supply and Utilization (continued)

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Soybean Meal										
Production					(Thousand Metric Tons)					
Baseline	165,122	172,092	175,401	178,363	182,958	186,486	189,825	194,015	197,983	201,848
Scenario 1	161,027	169,352	173,543	175,893	180,349	184,113	187,316	191,406	195,448	199,275
Percent Change	-2.48%	-1.59%	-1.06%	-1.38%	-1.43%	-1.27%	-1.32%	-1.34%	-1.28%	-1.27%
Consumption										
Baseline	162,560	169,579	173,013	176,107	180,656	184,203	187,570	191,700	195,656	199,516
Scenario 1	158,877	166,793	171,072	173,657	178,056	181,814	185,063	189,095	193,116	196,945
Percent Change	-2.27%	-1.64%	-1.12%	-1.39%	-1.44%	-1.30%	-1.34%	-1.36%	-1.30%	-1.29%
Ending Stocks										
Baseline	5,768	6,069	6,243	6,286	6,374	6,445	6,487	6,588	6,702	6,822
Scenario 1	5,356	5,703	5,961	5,984	6,064	6,150	6,190	6,288	6,406	6,524
Percent Change	-7.14%	-6.03%	-4.52%	-4.80%	-4.87%	-4.58%	-4.58%	-4.56%	-4.42%	-4.37%
Trade *										
Baseline	56,655	60,137	61,994	62,804	64,161	65,415	66,896	68,602	70,286	71,907
Scenario 1	54,520	58,498	60,491	60,863	62,049	63,673	65,023	66,656	68,326	69,918
Percent Change	-3.77%	-2.73%	-2.42%	-3.09%	-3.29%	-2.66%	-2.80%	-2.84%	-2.79%	-2.77%
Soybean Oil										
Production										
Baseline	39,020	40,765	41,647	42,446	43,638	44,587	45,498	46,618	47,694	48,753
Scenario 1	38,034	40,098	41,182	41,827	42,979	43,977	44,848	45,940	47,027	48,071
Percent Change	-2.53%	-1.64%	-1.12%	-1.46%	-1.51%	-1.37%	-1.43%	-1.46%	-1.40%	-1.40%
Consumption										
Baseline	39,063	40,488	41,453	42,156	43,383	44,331	45,289	46,427	47,488	48,554
Scenario 1	38,171	39,841	40,965	41,562	42,735	43,719	44,649	45,754	46,821	47,875
Percent Change	-2.28%	-1.60%	-1.18%	-1.41%	-1.49%	-1.38%	-1.41%	-1.45%	-1.40%	-1.40%
Ending Stocks										
Baseline	2,361	2,422	2,400	2,473	2,512	2,552	2,545	2,521	2,511	2,494
Scenario 1	2,267	2,307	2,308	2,358	2,386	2,428	2,412	2,381	2,372	2,352
Percent Change	-4.00%	-4.76%	-3.81%	-4.67%	-5.02%	-4.86%	-5.23%	-5.53%	-5.55%	-5.70%
Trade *										
Baseline	9,651	10,042	10,268	10,443	11,019	11,350	11,733	12,191	12,638	13,091
Scenario 1	9,458	9,708	9,938	10,027	10,525	10,814	11,153	11,581	12,011	12,456
Percent Change	-2.00%	-3.33%	-3.21%	-3.99%	-4.48%	-4.72%	-4.95%	-5.00%	-4.96%	-4.85%
Per Capita Consumption					(Kilograms)					
Baseline	5.78	5.92	6.00	6.03	6.14	6.20	6.27	6.36	6.44	6.51
Scenario 1	5.65	5.83	5.93	5.94	6.04	6.12	6.18	6.27	6.35	6.42
Percent Change	-2.28%	-1.60%	-1.18%	-1.41%	-1.49%	-1.38%	-1.41%	-1.45%	-1.40%	-1.40%

* Excludes intraregional trade.

World Rapeseed Sector Supply and Utilization

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Rapeseed										
Area Harvested				(Thousand Hectares)						
Baseline	28,729	29,388	29,904	30,355	30,612	30,935	31,345	31,743	32,145	32,587
Scenario 1	28,785	29,532	30,060	30,516	30,806	31,147	31,565	31,979	32,395	32,842
Percent Change	0.19%	0.49%	0.52%	0.53%	0.63%	0.69%	0.70%	0.75%	0.78%	0.78%
Production				(Thousand Metric Tons)						
Baseline	50,085	51,784	53,205	54,597	55,648	56,797	58,087	59,356	60,642	62,001
Scenario 1	49,836	51,703	53,148	54,542	55,643	56,819	58,115	59,405	60,708	62,072
Percent Change	-0.50%	-0.16%	-0.11%	-0.10%	-0.01%	0.04%	0.05%	0.08%	0.11%	0.11%
Beginning Stocks										
Baseline	2,860	3,034	3,050	3,061	3,146	3,183	3,199	3,224	3,254	3,279
Scenario 1	2,860	2,975	2,987	3,005	3,084	3,120	3,136	3,159	3,187	3,212
Percent Change	0.00%	-1.94%	-2.04%	-1.85%	-1.96%	-2.01%	-1.97%	-2.04%	-2.07%	-2.06%
Domestic Supply										
Baseline	52,945	54,818	56,254	57,658	58,794	59,981	61,285	62,580	63,896	65,281
Scenario 1	52,696	54,678	56,135	57,546	58,727	59,938	61,251	62,564	63,895	65,284
Percent Change	-0.47%	-0.25%	-0.21%	-0.19%	-0.11%	-0.07%	-0.06%	-0.03%	0.00%	0.00%
Crush										
Baseline	46,056	47,742	49,123	50,373	51,428	52,616	53,943	55,300	56,690	58,164
Scenario 1	45,918	47,706	49,091	50,338	51,430	52,631	53,956	55,323	56,718	58,188
Percent Change	-0.30%	-0.08%	-0.07%	-0.07%	0.00%	0.03%	0.02%	0.04%	0.05%	0.04%
Other Use										
Baseline	3,584	3,755	3,799	3,868	3,912	3,895	3,846	3,755	3,656	3,537
Scenario 1	3,532	3,714	3,768	3,853	3,906	3,901	3,864	3,783	3,694	3,585
Percent Change	-1.46%	-1.08%	-0.80%	-0.40%	-0.15%	0.14%	0.46%	0.76%	1.04%	1.35%
Residual										
Baseline	271	271	271	271	271	271	271	271	271	271
Scenario 1	271	271	271	271	271	271	271	271	271	271
Percent Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ending Stocks										
Baseline	3,034	3,050	3,061	3,146	3,183	3,199	3,224	3,254	3,279	3,308
Scenario 1	2,975	2,987	3,005	3,084	3,120	3,136	3,159	3,187	3,212	3,239
Percent Change	-1.94%	-2.04%	-1.85%	-1.96%	-2.01%	-1.97%	-2.04%	-2.07%	-2.06%	-2.07%
Domestic Use										
Baseline	52,945	54,818	56,254	57,658	58,794	59,981	61,285	62,580	63,896	65,281
Scenario 1	52,696	54,678	56,135	57,546	58,727	59,938	61,251	62,564	63,895	65,284
Percent Change	-0.47%	-0.25%	-0.21%	-0.19%	-0.11%	-0.07%	-0.06%	-0.03%	0.00%	0.00%
Trade *										
Baseline	7,472	8,088	8,304	8,493	8,675	8,868	9,086	9,330	9,591	9,866
Scenario 1	7,476	7,976	8,160	8,327	8,496	8,674	8,877	9,108	9,357	9,619
Percent Change	0.05%	-1.39%	-1.74%	-1.96%	-2.06%	-2.18%	-2.30%	-2.38%	-2.44%	-2.50%

World Rapeseed Sector Supply and Utilization (continued)

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Rapeseed Meal										
Production				(Thousand Metric Tons)						
Baseline	27,251	28,226	29,031	29,768	30,384	31,080	31,862	32,662	33,481	34,352
Scenario 1	27,170	28,203	29,011	29,745	30,383	31,087	31,866	32,672	33,494	34,362
Percent Change	-0.30%	-0.08%	-0.07%	-0.08%	0.00%	0.02%	0.01%	0.03%	0.04%	0.03%
Consumption										
Baseline	27,559	28,537	29,340	30,081	30,703	31,397	32,177	32,976	33,793	34,662
Scenario 1	27,489	28,513	29,317	30,058	30,702	31,402	32,182	32,985	33,806	34,672
Percent Change	-0.25%	-0.08%	-0.08%	-0.08%	0.00%	0.02%	0.01%	0.03%	0.04%	0.03%
Ending Stocks										
Baseline	314	322	333	339	339	342	345	351	357	366
Scenario 1	303	312	324	330	331	334	338	343	350	358
Percent Change	-3.72%	-3.34%	-2.70%	-2.54%	-2.43%	-2.34%	-2.28%	-2.19%	-2.14%	-2.13%
Trade *										
Baseline	2,404	2,738	2,946	3,008	3,121	3,214	3,291	3,369	3,446	3,626
Scenario 1	2,389	2,792	2,992	3,062	3,180	3,274	3,356	3,437	3,517	3,589
Percent Change	-0.62%	1.95%	1.58%	1.82%	1.89%	1.88%	1.97%	2.02%	2.04%	-1.03%
Rapeseed Oil										
Production										
Baseline	18,068	18,760	19,321	19,821	20,250	20,731	21,265	21,809	22,367	22,957
Scenario 1	18,009	18,744	19,307	19,808	20,252	20,738	21,272	21,821	22,381	22,970
Percent Change	-0.33%	-0.08%	-0.07%	-0.07%	0.01%	0.03%	0.03%	0.05%	0.06%	0.06%
Consumption										
Baseline	18,287	19,016	19,580	20,067	20,498	20,987	21,522	22,068	22,629	23,220
Scenario 1	18,237	19,005	19,567	20,056	20,501	20,994	21,530	22,081	22,644	23,233
Percent Change	-0.27%	-0.06%	-0.07%	-0.06%	0.02%	0.04%	0.04%	0.06%	0.06%	0.06%
Ending Stocks										
Baseline	427	429	428	440	451	453	453	452	448	443
Scenario 1	418	416	414	424	433	435	434	433	428	422
Percent Change	-2.18%	-3.13%	-3.24%	-3.58%	-3.86%	-3.95%	-4.14%	-4.35%	-4.49%	-4.63%
Trade *										
Baseline	1,591	1,631	1,708	1,759	1,830	1,909	1,981	2,045	2,101	2,158
Scenario 1	1,481	1,563	1,648	1,707	1,785	1,870	1,949	2,018	2,078	2,140
Percent Change	-6.91%	-4.15%	-3.53%	-2.99%	-2.45%	-2.02%	-1.64%	-1.32%	-1.07%	-0.85%
Per Capita Consumption					(Kilograms)					
Baseline	2.71	2.78	2.83	2.87	2.90	2.94	2.98	3.02	3.07	3.11
Scenario 1	2.70	2.78	2.83	2.87	2.90	2.94	2.98	3.02	3.07	3.12
Percent Change	-0.27%	-0.06%	-0.07%	-0.06%	0.02%	0.04%	0.04%	0.06%	0.06%	0.06%

* Excludes intraregional trade.

World Sunflower Sector Supply and Utilization

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Sunflower Seed										
Area Harvested				(Thousand Hectares)						
Baseline	24,273	24,401	24,392	24,474	24,513	24,538	24,600	24,680	24,759	24,850
Scenario 1	24,261	24,392	24,404	24,490	24,537	24,571	24,633	24,717	24,800	24,891
Percent Change	-0.05%	-0.04%	0.05%	0.07%	0.10%	0.13%	0.13%	0.15%	0.17%	0.16%
Production				(Thousand Metric Tons)						
Baseline	29,838	30,284	30,612	31,042	31,425	31,784	32,182	32,610	33,037	33,480
Scenario 1	29,828	30,287	30,642	31,074	31,469	31,841	32,241	32,675	33,108	33,552
Percent Change	-0.04%	0.01%	0.10%	0.10%	0.14%	0.18%	0.18%	0.20%	0.22%	0.21%
Beginning Stocks										
Baseline	1,884	2,032	2,089	2,105	2,136	2,179	2,198	2,215	2,238	2,258
Scenario 1	1,884	2,002	2,051	2,076	2,105	2,147	2,169	2,186	2,209	2,230
Percent Change	0.00%	-1.50%	-1.81%	-1.38%	-1.43%	-1.44%	-1.29%	-1.29%	-1.28%	-1.22%
Domestic Supply										
Baseline	31,722	32,316	32,701	33,147	33,561	33,962	34,380	34,825	35,275	35,737
Scenario 1	31,712	32,289	32,693	33,150	33,575	33,988	34,410	34,861	35,317	35,782
Percent Change	-0.03%	-0.09%	-0.02%	0.01%	0.04%	0.08%	0.09%	0.10%	0.12%	0.12%
Crush										
Baseline	26,228	26,695	27,040	27,421	27,746	28,106	28,487	28,880	29,292	29,706
Scenario 1	26,276	26,738	27,084	27,480	27,817	28,181	28,567	28,967	29,381	29,797
Percent Change	0.18%	0.16%	0.16%	0.21%	0.25%	0.27%	0.28%	0.30%	0.31%	0.31%
Other Use										
Baseline	3,387	3,458	3,481	3,515	3,561	3,583	3,602	3,631	3,650	3,680
Scenario 1	3,359	3,425	3,458	3,490	3,536	3,562	3,581	3,610	3,631	3,661
Percent Change	-0.84%	-0.96%	-0.66%	-0.72%	-0.72%	-0.59%	-0.59%	-0.58%	-0.53%	-0.52%
Residual										
Baseline	75	75	75	75	75	75	75	75	75	75
Scenario 1	75	75	75	75	75	75	75	75	75	75
Percent Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ending Stocks										
Baseline	2,032	2,089	2,105	2,136	2,179	2,198	2,215	2,238	2,258	2,276
Scenario 1	2,002	2,051	2,076	2,105	2,147	2,169	2,186	2,209	2,230	2,249
Percent Change	-1.50%	-1.81%	-1.38%	-1.43%	-1.44%	-1.29%	-1.29%	-1.28%	-1.22%	-1.21%
Domestic Use										
Baseline	31,722	32,316	32,701	33,147	33,561	33,962	34,380	34,825	35,275	35,737
Scenario 1	31,712	32,289	32,693	33,150	33,575	33,988	34,410	34,861	35,317	35,782
Percent Change	-0.03%	-0.09%	-0.02%	0.01%	0.04%	0.08%	0.09%	0.10%	0.12%	0.12%
Trade *										
Baseline	513	615	757	856	947	1,012	1,083	1,163	1,238	1,318
Scenario 1	511	577	708	811	905	972	1,043	1,125	1,200	1,280
Percent Change	-0.33%	-6.18%	-6.50%	-5.30%	-4.47%	-3.98%	-3.71%	-3.33%	-3.09%	-2.94%

World Sunflower Sector Supply and Utilization (continued)

	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
Sunflower Meal										
Production				(Thousand Metric Tons)						
Baseline	11,614	11,806	11,958	12,129	12,268	12,419	12,579	12,745	12,918	13,092
Scenario 1	11,636	11,824	11,978	12,155	12,300	12,454	12,616	12,785	12,959	13,134
Percent Change	0.18%	0.16%	0.16%	0.22%	0.26%	0.28%	0.29%	0.31%	0.32%	0.32%
Consumption										
Baseline	11,276	11,483	11,636	11,808	11,949	12,099	12,259	12,424	12,596	12,770
Scenario 1	11,301	11,502	11,655	11,834	11,981	12,134	12,296	12,464	12,638	12,813
Percent Change	0.22%	0.16%	0.16%	0.22%	0.27%	0.28%	0.30%	0.32%	0.33%	0.33%
Ending Stocks										
Baseline	257	262	266	268	270	272	274	277	280	284
Scenario 1	253	258	263	266	267	269	271	274	278	281
Percent Change	-1.41%	-1.42%	-1.14%	-1.05%	-1.01%	-0.97%	-0.92%	-0.88%	-0.86%	-0.85%
Trade *										
Baseline	2,652	2,696	2,683	2,675	2,677	2,688	2,695	2,702	2,713	2,728
Scenario 1	2,655	2,699	2,685	2,677	2,680	2,691	2,698	2,705	2,716	2,731
Percent Change	0.13%	0.09%	0.08%	0.11%	0.12%	0.11%	0.12%	0.12%	0.12%	0.12%
Sunflower Oil										
Production										
Baseline	10,680	10,875	11,016	11,171	11,304	11,452	11,609	11,771	11,940	12,111
Scenario 1	10,700	10,893	11,034	11,195	11,333	11,483	11,642	11,807	11,977	12,149
Percent Change	0.18%	0.16%	0.17%	0.22%	0.26%	0.27%	0.29%	0.30%	0.31%	0.31%
Consumption										
Baseline	10,294	10,518	10,673	10,823	10,950	11,105	11,262	11,424	11,594	11,766
Scenario 1	10,320	10,538	10,690	10,848	10,979	11,135	11,296	11,460	11,631	11,803
Percent Change	0.25%	0.19%	0.15%	0.23%	0.27%	0.28%	0.30%	0.31%	0.32%	0.32%
Ending Stocks										
Baseline	427	443	443	449	462	467	472	477	481	484
Scenario 1	421	434	436	441	453	459	464	469	473	476
Percent Change	-1.57%	-2.03%	-1.59%	-1.75%	-1.82%	-1.68%	-1.70%	-1.72%	-1.66%	-1.63%
Trade *										
Baseline	3,236	3,349	3,396	3,446	3,516	3,600	3,685	3,774	3,869	3,972
Scenario 1	3,240	3,354	3,401	3,454	3,525	3,610	3,697	3,787	3,883	3,986
Percent Change	0.13%	0.15%	0.17%	0.24%	0.26%	0.28%	0.31%	0.33%	0.34%	0.35%
Per Capita Consumption					(Kilograms)					
Baseline	1.52	1.54	1.54	1.55	1.55	1.55	1.56	1.56	1.57	1.58
Scenario 1	1.53	1.54	1.55	1.55	1.55	1.56	1.56	1.57	1.58	1.58
Percent Change	0.25%	0.19%	0.15%	0.23%	0.27%	0.28%	0.30%	0.31%	0.32%	0.32%

* Excludes intraregional trade.

Appendix 3: Baseline 2007-08 world production, consumption and price data

	Area (million hectares)	Production (million tonnes)	Trade (million tonnes)	Consumption (million tonnes)	Price ($/tonne)
Corn	159	790	97	777	218
Soybeans	91	218	78	n/a	469
Canola	28	48	4	n/a	644
Wheat	217	611	115	618	314
Barley	57	133	18	176	242
Sunflower	22	27	1	n/a	745
Sorghum	41	63	9	63	299
Soymeal	n/a	158	55	157	314
Soy oil	n/a	37	10	37	1,151
Rapemeal	n/a	27	4	27	298
Rape oil	n/a	18	2	18	1,410
Sun meal	n/a	11	3	10	191
Sun oil	n/a	10	3	9	1,639

Note: All values rounded to nearest million; n/a = not applicable.